BLM LIBRARY
88076962

Technical Report
Volume 2: Appendices

Water Resources Environmental Impact Statement Thousand Springs Power Plant Northeastern Nevada

November 1989

U.S. Department of the Interior
Bureau of Land Management
Elko District Office
Elko, Nevada

90266B

#12497503 68
88076962

Technical Report
Volume 2: Appendices

TD
195
.E4
E646
1989e
v.2

Water Resources
Environmental Impact Statement
Thousand Springs Power Plant
Northeastern Nevada

November 1989

U.S. Department of the Interior
Bureau of Land Management
Elko District Office
Elko, Nevada

90266B

TABLE OF CONTENTS

VOLUME 2

		Page
APPENDIX A	GEOPHYSICAL DATA REPORT	A-1
APPENDIX B	SURFACE WATER RECORDS AND ESTIMATES	B-1
APPENDIX C	NUMERICAL GROUNDWATER FLOW MODEL DATA REPORT	C-1
APPENDIX D	BOREHOLE GEOPHYSICAL LOGS	D-1
APPENDIX E	LITHOLOGIC AND WELL CONSTRUCTION LOGS	E-1
APPENDIX F	AQUIFER TESTING PROCEDURES	F-1
APPENDIX G	WATER SAMPLING AND ANALYSIS PROCEDURES	G-1
APPENDIX H	LABORATORY GEOCHEMICAL, WATER QUALITY, AND SOIL SAMPLING DATA REPORTS	H-1
APPENDIX I	WELL AND SPRING INVENTORY	I-1
APPENDIX J	CALCULATION OF GROUNDWATER FLOW VOLUME	J-1

APPENDIX A
GEOPHYSICAL DATA REPORT

APPENDIX A-1

TDEM PROFILES IN TOANO DRAW

TDEM data interpretation requires comparison and designation of resistivity values to materials followed by integration of the data into geologic cross sections. The profiles provide a tool for analyzing subsurface materials. Profile transects were chosen for this project to cover areas of primary interest and of greatest data density. Generally, transects that cross major lithologic boundaries, structures, or zones of interest are selected. In addition, one longitudinal cross section along the Toano Draw valley axis was developed.

The results of these profiles, when integrated with geologic and hydrologic data, assist in the interpretation of stratigraphic units and structures. This data is then incorporated into hydrogeologic models developed for Toano Draw Subbasin.

Profiles I, Ia, and Ib

Three TDEM profiles are located in the northernmost portion of the survey area (Figure 3-2). Profile I (Figure A-1.1) lies along Thousand Springs Creek; Profiles Ia (Figure A-1.2) and Ib (Figure A-1.3) are farther north in Thousand Springs Valley. These profiles suggest that subsurface conditions here are more complex than farther south in Toano Draw. Thick sections of relatively shallow, low resistivity, fine-grained sediments within most of this area suggest a low probability of encountering aquifer materials. Drilling in this area (WCC Wells TW-1, MW-1, MW-4, and MW-6) has produced only minor quantities of water. Aquifer tests performed on TW-1 and MW-1 confirm low aquifer yields.

Wells TW-1, MW-1, MW-4, and MW-6 are located along Profile I at TDEM Soundings EM-20, EM-21, and EM-19, respectively (Figure A-1.1). Coarse-grained materials (19 ohm-m) at shallow depths are located beneath EM-20 and EM-21. This is evidenced by Well MW-1 which encountered sand throughout its upper 200 feet. However, pump tests indicate that, at least to the north, apparently favorable resistivities may not correlate with good water production. This disparity may be partly due to a large volume of volcanogenic material near the surface in the northern part of the basin. As an example, TDEM Sounding EM-19 recorded a resistivity value of 14 ohm-m, a favorable value for water production. WCC Well MW-6, drilled at the same location, encountered volcaniclastic sediments, generally considered poor aquifer materials, in its upper 660 feet.

Three TDEM soundings located near the valley margins, EM-19, EM-28, and EM-62, have higher resistivity values interpreted as bedrock at intermediate depth. This was confirmed by Well MW-6 (EM-19) which encountered Paleozoic rocks at about 630 feet.

Profile II

Profile II (Figure A-1.4) trends east from near the Winecup Ranch along a pipeline road to the southern base of Ninemile Mountain (Figure 3-2). Pump tests of two agricultural wells, 41-65-35ad and 41-65-35bd, approximately 1 mile south of EM-57, indicate high hydraulic conductivities and relatively high well yields of 600 -1000 gpm (Guyton 1982). Projection of these wells onto the profile suggests that the water-bearing unit falls within the zone of sediments that have measured resistivity values considered favorable for potential aquifer material. Some discrepancy in the thickness of the aquifer between the well logs and the TDEM data may be due to the projection angle of the wells along the profile.

The TDEM data also suggest that distinct eastern and western aquifers may exist along the profile. WCC Well MW-12, located about 2 miles south of the eastern zone and projected into the profile at Site EM-55, had relatively high yield. A relatively thick zone of 9-13 ohm-m material located only beneath the western zone might be attributed to an intermediate clay unit.

TDEM data suggest that the easternmost part of the profile overlies a section devoid of coarse-grained sediments. The western end of the profile traverses a fault as evidenced by a relatively elevated basement at Station EM-62.

Profile III

Profile III (Figure A-1.5), located in the northern portion of Toano Draw, trends east from Indian Springs to the southern end of Ninemile Mountain (Figure 3-2). The transect overlies a relatively thick section of coarse-grained alluvium, which is thickest in the central and eastern part of the valley. The intermediate clay unit detected in Profile II is absent in this area. Volcanic clays are restricted to the western part of the profile between EM-18 and EM-61. The TDEM data indicate shallow Paleozoic basement along the eastern part of the profile, confirmed by carbonate rocks outcropping just east of EM-16.

Pump test data for nearby wells suggest the coarse-grained material at this location serves as an aquifer. Well yields for agricultural wells, 41-65-35ad and 41-65-35bd, located about ½ mile north of EM-23, are reported to range from 600-1000 gpm (Guyton 1982). WCC Well MW-12, at Site EM-14 near the center of the profile, has also provided substantial yields. Fivemile Draw well, located at EM-51, currently used as a principal livestock well for the area, is situated above a significant thickness of potential aquifer material.

Profile IV

In the central portion of Toano Draw, Profile IV (Figure A-1.6) trends east from exposed volcanic rocks on the eastern flank of the Windermere Hills to Toano Well #1 and then trends northeast to the head of Twentyone Mile Draw (Figure 3-2). In general, the stratigraphy along this profile is more complex and less continuous than to the north. The eastern portion of the profile is composed primarily of a lower resistivity, fine-grained unit, and a thin wedge of higher resistivity material.

The western portion of the profile is composed of a relatively high resistivity unit. Located between Stations EM-105 and EM-46 is a unit with resistivities ranging from 30-35 ohm-m. This is considered to be at the upper limit of resistivity that may indicate potential aquifer materials. This unit is overlain by a more resistive (65-85 ohm-m) unit that exceeds the resistivity limits for potential aquifer materials. The three westernmost TDEM sites overlie a relatively thin (200-300 feet thick) zone of 15-16 ohm-m material. Poor water production from Toano Well #1 and WCC Well MW-2 and resistivity data from TDEM Sites EM-12 and EM-13, both located above this zone, suggest this unit is a poor aquifer. WCC Well MW-16, a 660-foot-deep well drilled at Station EM-40, encountered little water.

Profile V

Profile V (Figure A-1.7) combines stations from Profiles III and IV (Figure 3-2). Additionally, Stations EM-47 and EM-107, near the center of the profile, have been included. These two stations overlie a relatively thick zone of coarse-grained materials.

Profile VI

Profile VI (Figure A-1.8) trends east along the center portion of Toano Draw at about the latitude of Hunter Draw (Figure 3-2). It is underlain by a wedge of 15-30 ohm-m, coarse-grained alluvium near the valley center. Well MW-3, completed within this zone, and MW-15, projected from about a mile south, had relatively high pumping yields.

The stratigraphy suggested by the resistivity data is interpreted as a coarse-grained unit underlying a relatively thick alluvial unit. These units are underlain by a lower resistivity tuffaceous volcanic unit along a west dipping contact.

Profile VII

Profile VII (Figure A-1.9) trends east from WCC Well MW-5 in the Deadman Creek drainage to Eightyfoot well (Figure 3-2). It is underlain by a relatively thick section of coarse-grained sediments near its western end along the trend of Deadman Creek. Well MW-14, drilled near the thickest part of this unit, consists of coarse alluvial materials to 507 feet. The lithologic log from Sun Exploration SP 3-13, projected from ½ mile north, indicates 800 feet of "valley fill" at the top of the hole. The top of volcanic rocks occurs at a depth of about 1500 feet. The TDEM interpretation is consistent with these well logs providing correlation between the 15-30 ohm-m unit and relatively coarse-grained deposits.

A relatively thin wedge of 16-18 ohm-m sediments, located farther east along the profile, is probably comprised of coarse-grained materials. However, its small volume may minimize its potential as a significant aquifer. Much of the upper part of the eastern portion of the profile is underlain by a relatively thick unit interpreted as volcaniclastic rocks.

Almost the entire width of the upper section of the profile consists of alluvial clays. This unit is present near the ground surface near Toano Well #2 (EM-10). Communications with Winecup Ranch personnel indicate that this well produces only a few gallons of water per minute.

Resistivity values believed associated with volcanic clays (<8 ohm-m) were found at only a few TDEM stations along the profile and in SP 3-13, indicating a unit rich in volcanic clay may be present at depths greater than 1500 feet.

The western end of this profile crosses a fault probably associated with the frontal faults mapped along the eastern side of the Windermere Hills (Figure 3-1). Station EM-6 indicated a higher resistivity unit, believed to be bedrock, at a depth of 300 feet, and Well MW-5, which encountered bedrock at approximately 200 feet, are both believed to be located on the western, upthrown side of the fault.

Profile VIII

Profile VIII (Figure A-1.10) trends northeast across Valley Pass in the southernmost part of Toano Draw. A small wedge of material with resistivity ranging from 15-17 ohm-m occurs in the center of this profile. These sediments may be comparable to coarse-grained deposits of similar resistivity present in the center of Profile VI. The drillers log of a water well in this vicinity, 38-67-29d, shows relatively thick sequences of coarse-grained material for its entire depth of 792 feet. A high resistivity surficial unit is present and appears to be generally thicker and more extensive to the north. Alluvial clays are absent except at the easternmost site (EM-95). Tuffaceous volcanic rocks appear much shallower along this profile than to the north. This data and the regional gravity interpretation by West (1987) suggest that the Paleozoic basement is shallower (<6000 feet) at Valley Pass than at areas to the north.

The substantial difference in TDEM values between EM-97 and EM-96 at the western end of the transect might be attributed to faulting. The resistivity value of the deepest layer at EM-97 is 1140 ohm-m; however, at EM-96, a mile to the east, the layer at the same elevation records a value of 140 ohm-m. This high resistivity layer is probably associated with Paleozoic bedrock. It occurs at an anomalously shallow depth indicating the upthrown side of the fault is to the east. A similar northwest-trending structure is indicated by gravity and geologic data. In addition, the inversion curve developed for EM-96 suggests that the fault is nearer that site than EM-97.

Profile IX

This south-trending profile (Figure A-1.11) is located along the northeastern margin of Toano Draw near the head of Twentyone Mile Draw. Resistivity data for this profile indicate subsurface materials consisting predominantly of fine-grained sediments. Drillers logs of Toilet Wells #1 and #2, located near soundings EM-37 and EM-35, respectively, show almost all fine-grained materials and minimal water production. Inversion curves for EM-39 and EM-40, at the northern portion of the line, suggest a coarse-grained layer is located near the surface. A shallow, thin layer of higher resistivity material occurs along the remainder of the profile.

TDEM Station EM-40, at the northern end of the profile, is interpreted to lie above a layer of coarse-grained material. Well MW-16, drilled at this location, encountered only fine-grained materials to a depth of 600 feet, which conflicts with the TDEM data. An alternative explanation for this 17 ohm-m unit might be that it is composed of dry clay.

An additional objective of this transect was to detect any groundwater pathways below Twentyone Mile Draw. The TDEM line was oriented normal to the flow of the surface drainage. No data were obtained which indicated that such a pathway exists.

Profile X

This northwest-trending profile (Figure A-1.12) is situated primarily within volcaniclastic sediments. The contact between this unit and alluvial fan deposits occurs to the east along the eastern margin of Toano Draw. Fivemile Draw Well is located at the southern end of the profile and station EM-15 terminates the northern end. In general, this profile indicates a predominance of fine-grained tuffaceous and alluvial materials. The only evidence for coarse-grained materials is at Fivemile Draw Well (EM-51) where a thin layer was detected.

Profile XI

This north-trending profile (Figures A-1.13a and A-1.13b) provides a longitudinal section of Toano Draw along the basin axis from Valley Pass to Thousand Springs Valley. Resistivity values indicate the southern two-thirds of the profile are comprised mostly of coarse-grained alluvium except beneath Toano Well #2 (EM-10), where lower resistivity material is present near the surface. The northern third of the Basin is underlain by a thick sequence of material interpreted to be interbedded welded and tuffaceous volcaniclastic sediments which provide a moderately high resistivity signature (28-37 ohm-m). Volcanically derived clay layers were detected in the northern part of the basin south of Thousand Springs Creek (EM-58, EM-23, and EM-109) and at the southernmost end of the valley (EM-93).

Profile XII

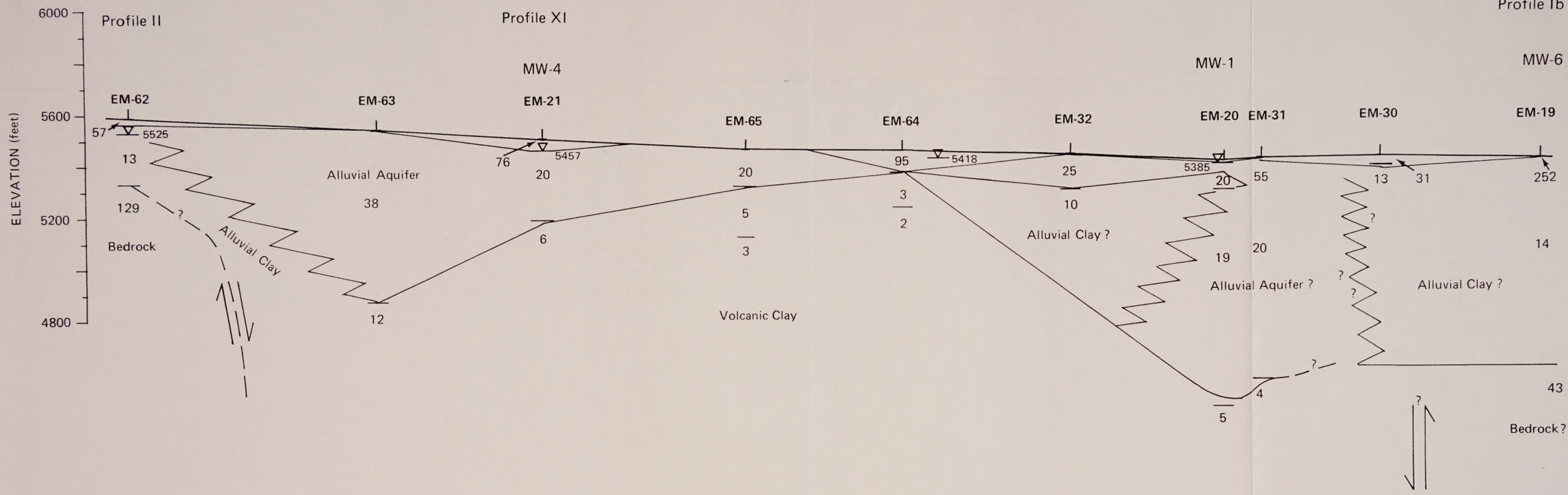
Profile XII (Figure A-1.14), located north of Montello in Tecoma Valley, trends southeast from west of Dake Reservoir to the base of the northern end of the Pequop Mountains (Figure 3-2). The transect overlies a thick sequence of materials with resistivities ranging from 24 to 30 ohm-meters. These resistivity values have been considered, in conjunction with other evidence, to suggest that coarse-grained sediments with relatively high groundwater transmitting capabilities are present along the profile. Evidence supporting this interpretation includes:

- Relatively high water production rates from large-capacity wells in the area adjacent to the profile.
- Well logs of existing water wells indicate thick sequences of coarse-grained materials.
- Gravity data suggest that thick sequences (>9000 feet) of sedimentary material exist in the area.

The TDEM data suggest that the bottom of the coarse-grained unit overlies low-resistivity materials, interpreted to be volcaniclastic clays. The presence of alluvial clays (8-15 ohm-meters) is indicated at the southeast end of the transect. A wedge of alluvial clays is also indicated at the northwest end of the profile. The difference in the apparent bedrock depth between soundings EM-69 and EM-68 is believed due to faulting.

PROFILE I

SOUTHWEST — NORTHEAST



LEGEND

EM-62 TDEM Sounding Stations

▽ Measured Water Elevation

Resistivities in ohm-meters

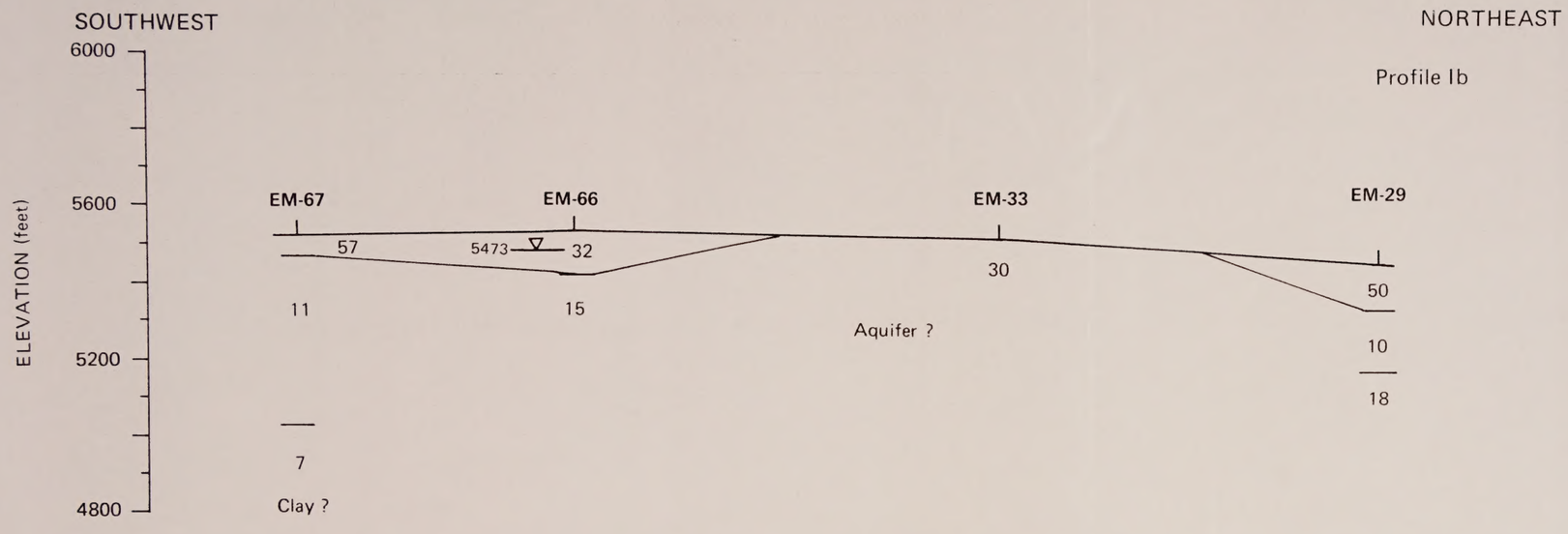
Resistivities and Thicknesses Interpreted from TDEM Sounding Data

Unit Contacts Inferred between Sites Based on Similar TDEM Resistivities, Geologic Surface Mapping and Well Logs

Vertical Scale: 1" = 400'
Horizontal Scale: 1" = 4000'

Project No. 90270B	Thousand Springs Energy Park	TDEM PROFILE I	Figure A-1.1
Woodward-Clyde Consultants			

PROFILE Ia



LEGEND

EM-29 TDEM Sounding Stations

∇ Measured Water Elevation

Resistivities in ohm-meters

Resistivities and Thicknesses Interpreted from TDEM Sounding Data

Unit Contacts Inferred between Sites Based on Similar TDEM Resistivities, Geologic Surface Mapping and Well Logs

Vertical Scale: 1" = 400'
Horizontal Scale: 1" = 4000'

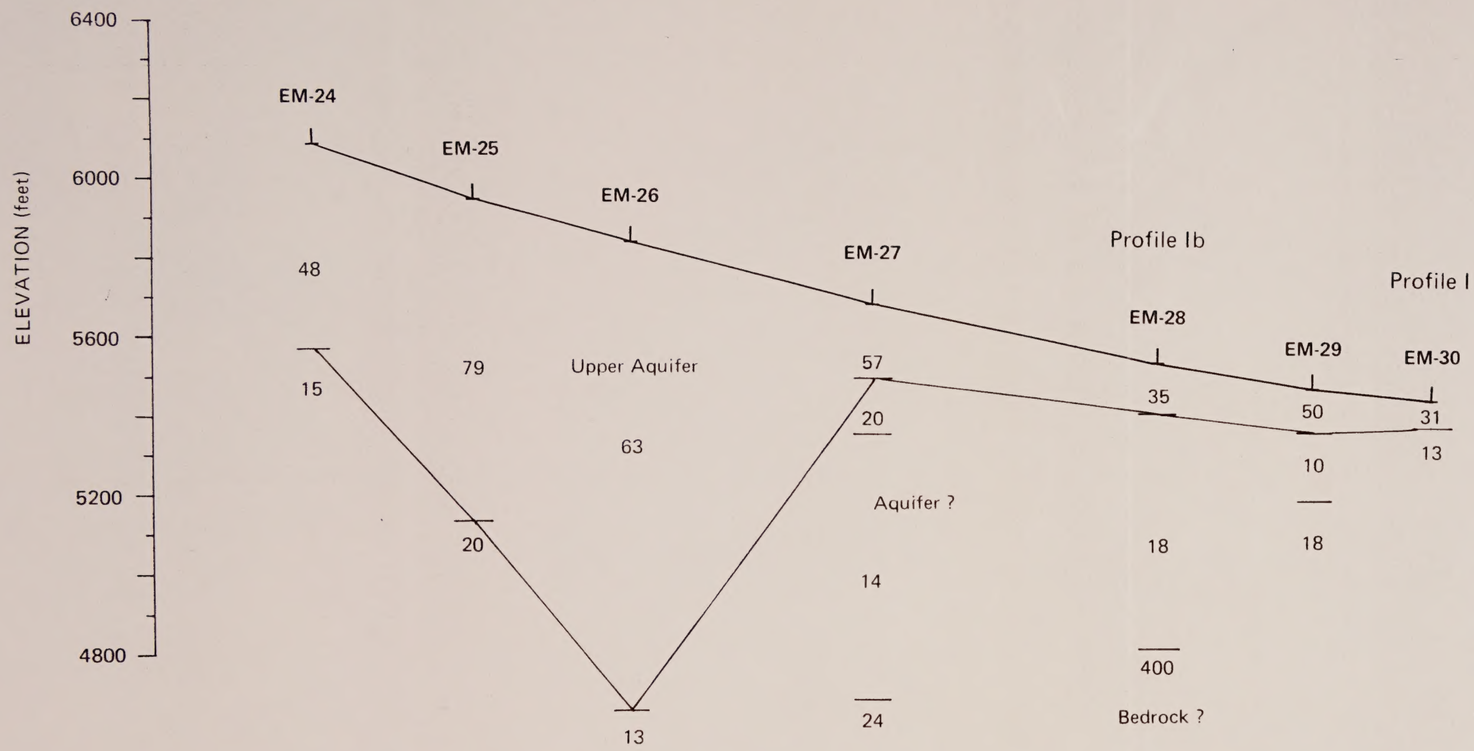
Project No. 90270B	Thousand Springs Energy Park	TDEM PROFILE Ia	Figure A-1.2
Woodward-Clyde Consultants			

Bull Mountains

PROFILE Ib

NORTHWEST

SOUTHEAST



LEGEND

EM-30 TDEM Sounding Stations

∇ Measured Water Elevation

Resistivities in ohm-meters

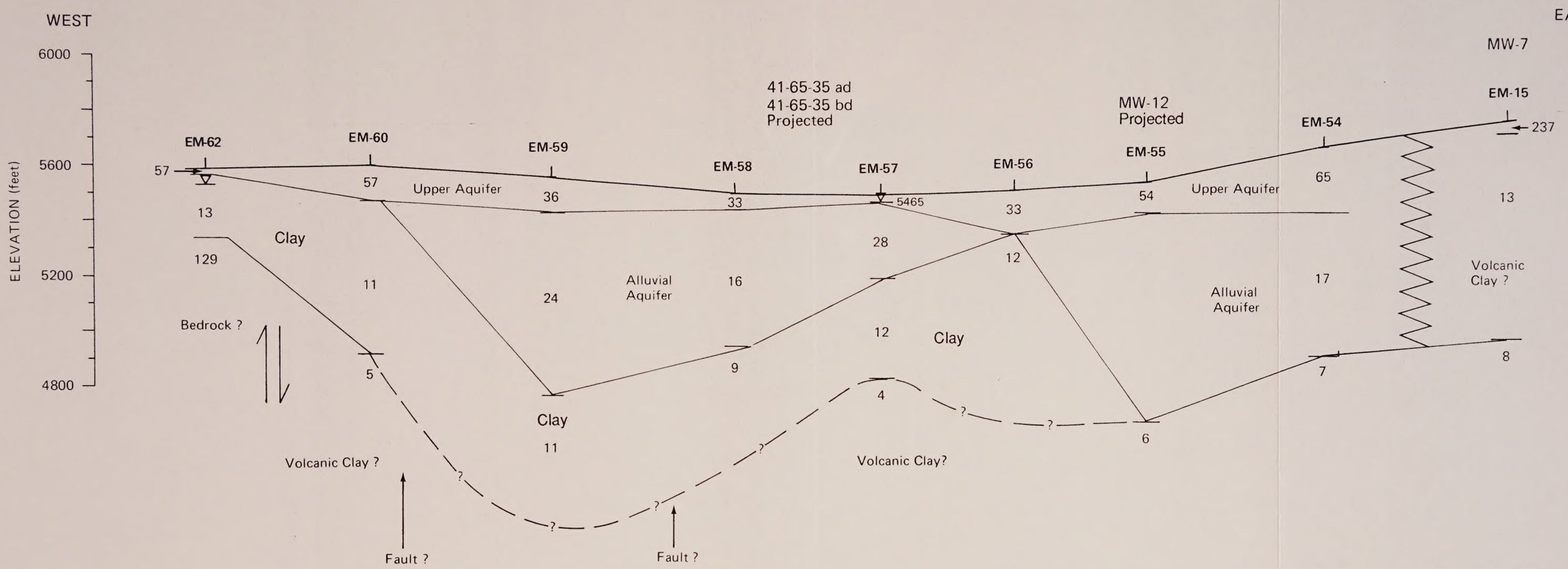
Resistivities and Thicknesses Interpreted from TDEM Sounding Data

Unit Contacts Inferred between Sites Based on Similar TDEM Resistivities, Geologic Surface Mapping and Well Logs

Vertical Scale: 1" = 400'
Horizontal Scale: 1" = 4000'

Project No. 90270B	Thousand Springs Energy Park	TDEM PROFILE Ib	Figure A-1.3
Woodward-Clyde Consultants			

PROFILE II



LEGEND

EM-62 TDEM Sounding Stations

▽ Measured Water Elevation

Resistivities in ohm-meters

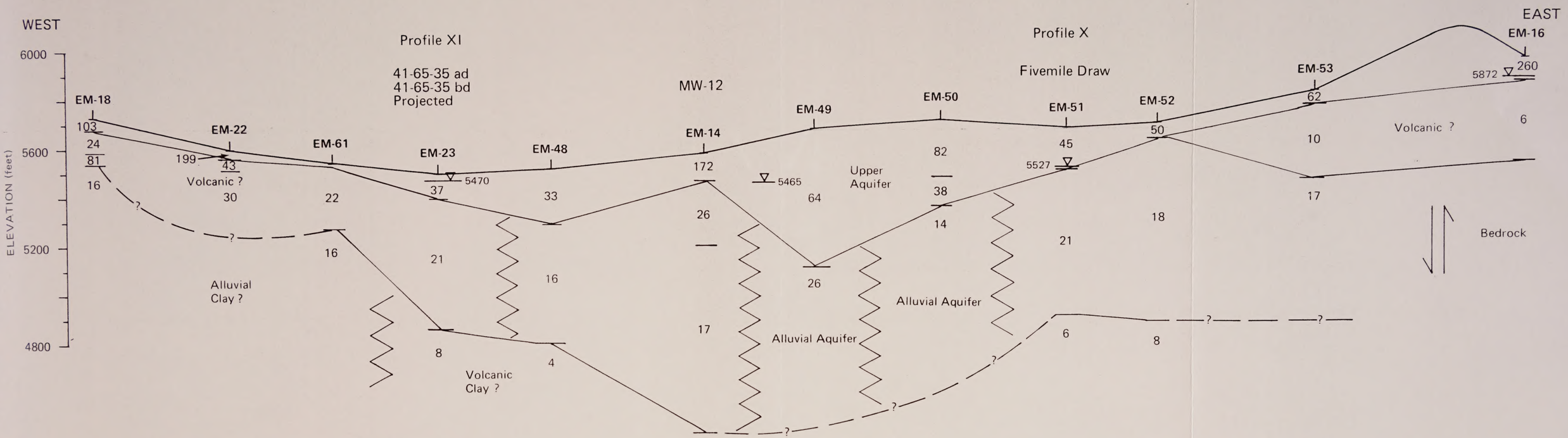
Resistivities and Thicknesses
Interpreted from TDEM Sounding Data

Unit Contacts Inferred between Sites
Based on Similar TDEM Resistivities,
Geologic Surface Mapping and Well Logs

Vertical Scale: 1" = 400'
Horizontal Scale: 1" = 4000'

Project No. 90270B	Thousand Springs Energy Park	TDEM PROFILE II	Figure A-1.4
Woodward-Clyde Consultants			

PROFILE III



LEGEND

EM-18 TDEM Sounding Stations

▽ Measured Water Elevation

Resistivities in ohm-meters

Resistivities and Thicknesses
Interpreted from TDEM Sounding Data

Unit Contacts Inferred between Sites
Based on Similar TDEM Resistivities,
Geologic Surface Mapping and Well Logs

Vertical Scale: 1" = 400'
Horizontal Scale: 1" = 4000'

Project No. 90270B	Thousand Springs Energy Park	TDEM PROFILE III	Figure A-1.5
Woodward-Clyde Consultants			

LEGEND

EM-13 TDEM Sounding Stations

Measured Water Elevation

Resistivities in ohm-meters

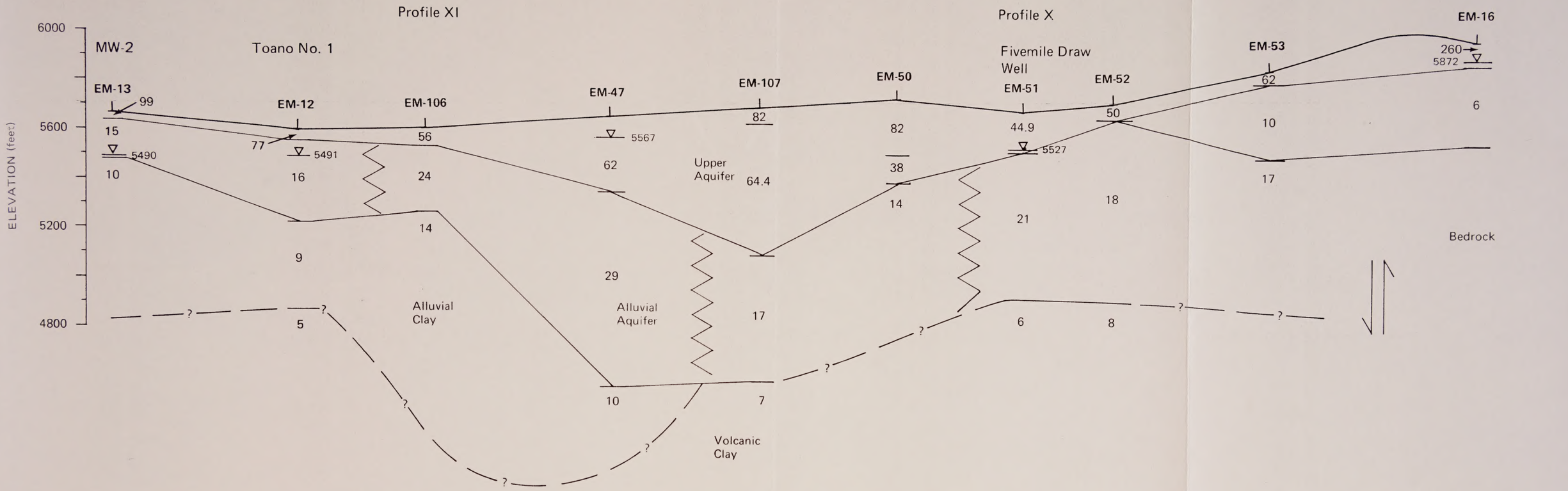
Resistivities and Thicknesses Interpreted from TDEM Sounding Data

Unit Contacts Inferred between Sites Based on Similar TDEM Resistivities, Geologic Surface Mapping and Well Logs

Vertical Scale: 1" = 400'
Horizontal Scale: 1" = 4000'

Project No. 90270B	Thousand Springs Energy Park	TDEM PROFILE IV	Figure A-1.6
Woodward-Clyde Consultants			

PROFILE V



LEGEND

EM-13 TDEM Sounding Stations

▽ Measured Water Elevation

Resistivities in ohm-meters

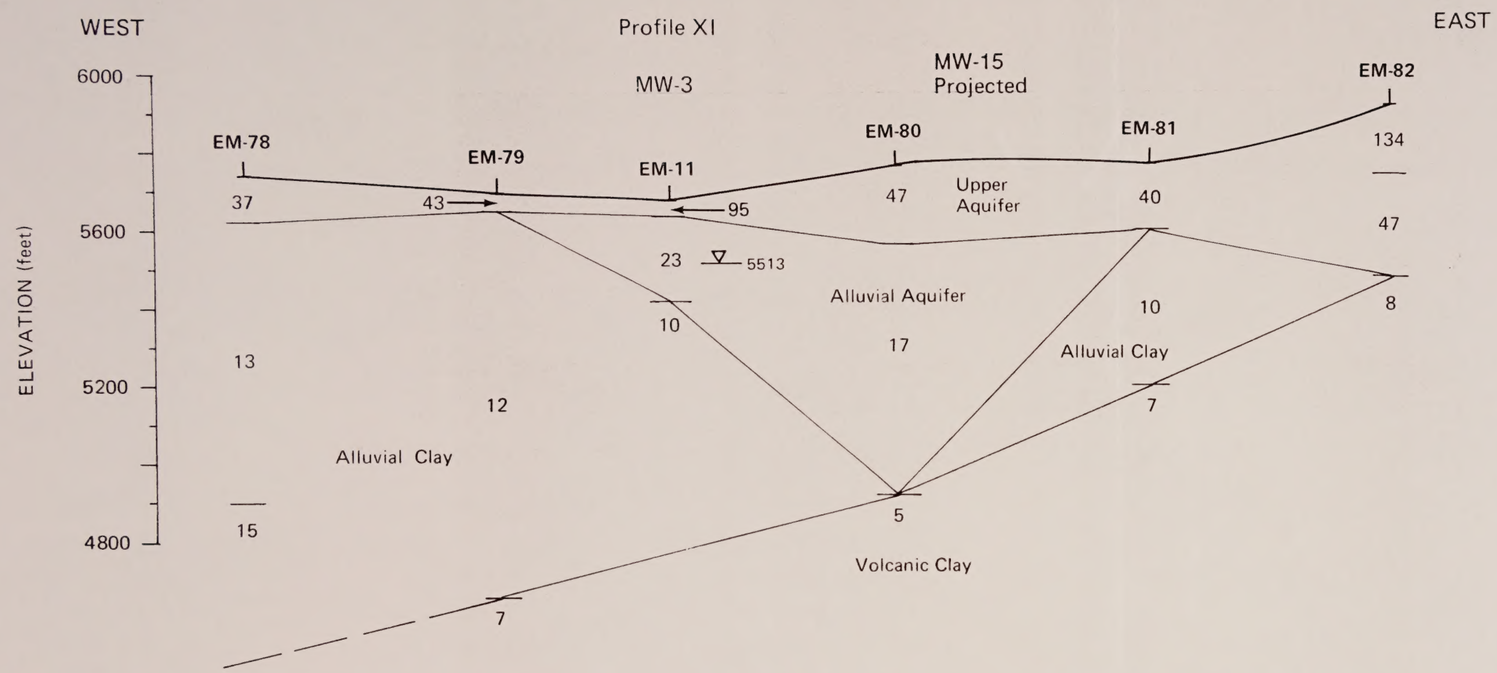
Resistivities and Thicknesses Interpreted from TDEM Sounding Data

Unit Contacts Inferred between Sites Based on Similar TDEM Resistivities, Geologic Surface Mapping and Well Logs

Vertical Scale: 1" = 400'
Horizontal Scale: 1" = 4000'

Project No. 90270B	Thousand Springs Energy Park	TDEM PROFILE V	Figure A-1.7
Woodward-Clyde Consultants			

PROFILE VI



LEGEND

EM-82 TDEM Sounding Stations

▽ Measured Water Elevation

Resistivities in ohm-meters

Resistivities and Thicknesses
Interpreted from TDEM Sounding Data

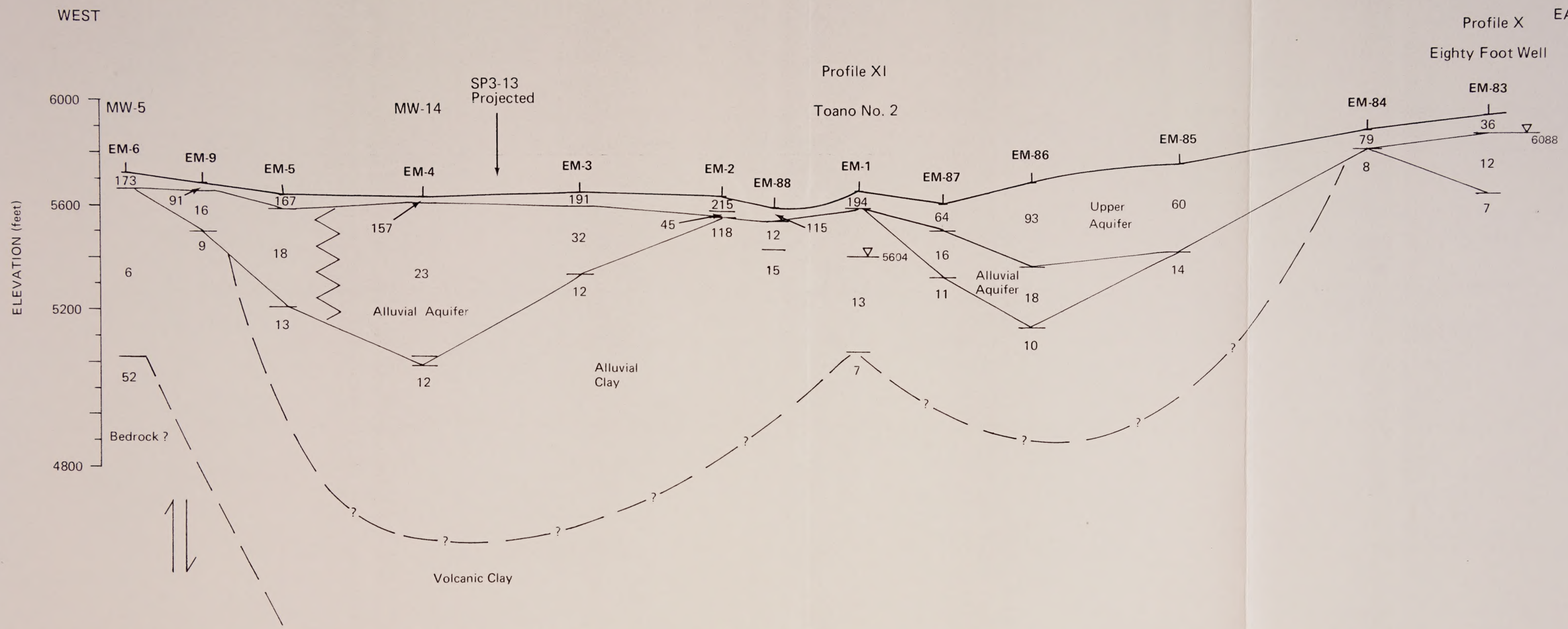
Unit Contacts Inferred between Sites
Based on Similar TDEM Resistivities,
Geologic Surface Mapping and Well Logs

Vertical Scale: 1" = 400'
Horizontal Scale: 1" = 4000'

Project No. 90270B	Thousand Springs Energy Park	TDEM PROFILE VI	Figure A-1.8
Woodward-Clyde Consultants			

Bull Mountains

PROFILE VII



LEGEND

EM-6 TDEM Sounding Stations

▽ Measured Water Elevation

Resistivities in ohm-meters

Resistivities and Thicknesses
Interpreted from TDEM Sounding Data

Unit Contacts Inferred between Sites
Based on Similar TDEM Resistivities,
Geologic Surface Mapping and Well Logs

Vertical Scale: 1" = 400'
Horizontal Scale: 1" = 4000'

Project No. 90270B	Thousand Springs Energy Park	TDEM PROFILE VII	Figure A-1.9
Woodward-Clyde Consultants			

Bull Mountains

Federal Coal Ownership

...n Coal Requested for Exchange

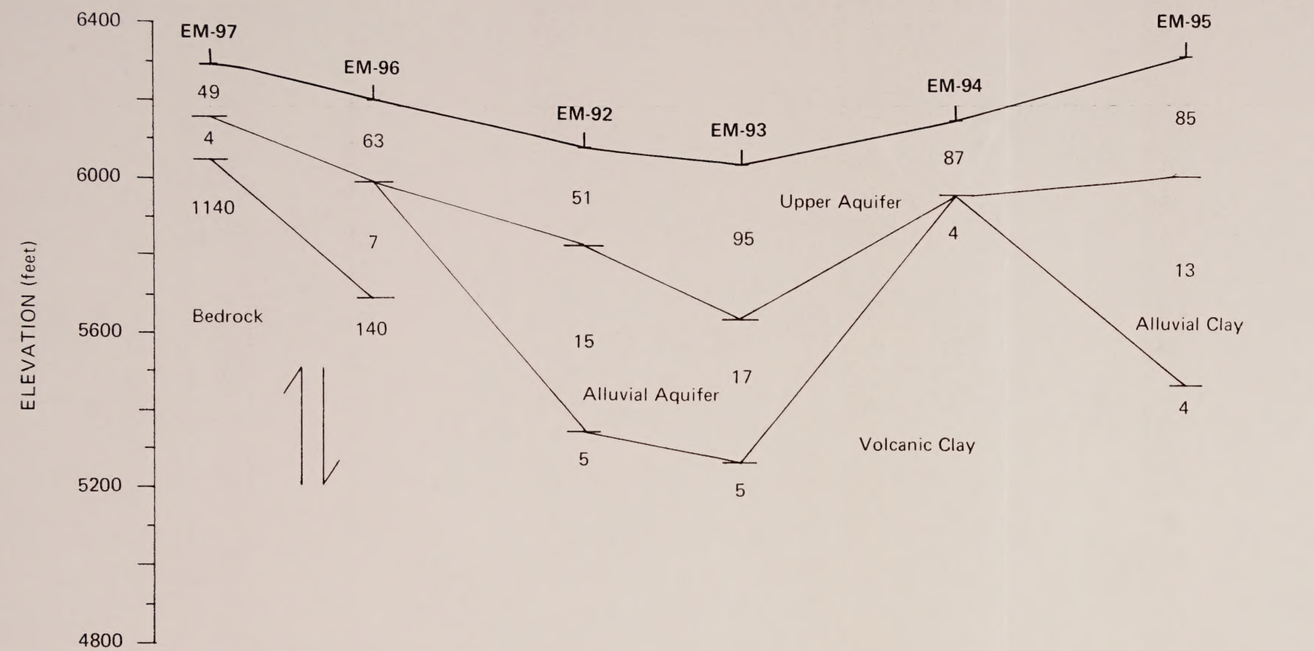
Coal Ownership

...Lands Considered for Leasing

...Minerals Coal Ownership

...of Land Management Surface Ownership

PROFILE VIII



LEGEND

EM-95 TDEM Sounding Stations

▽ Measured Water Elevation

Resistivities in ohm-meters

Resistivities and Thicknesses Interpreted from TDEM Sounding Data

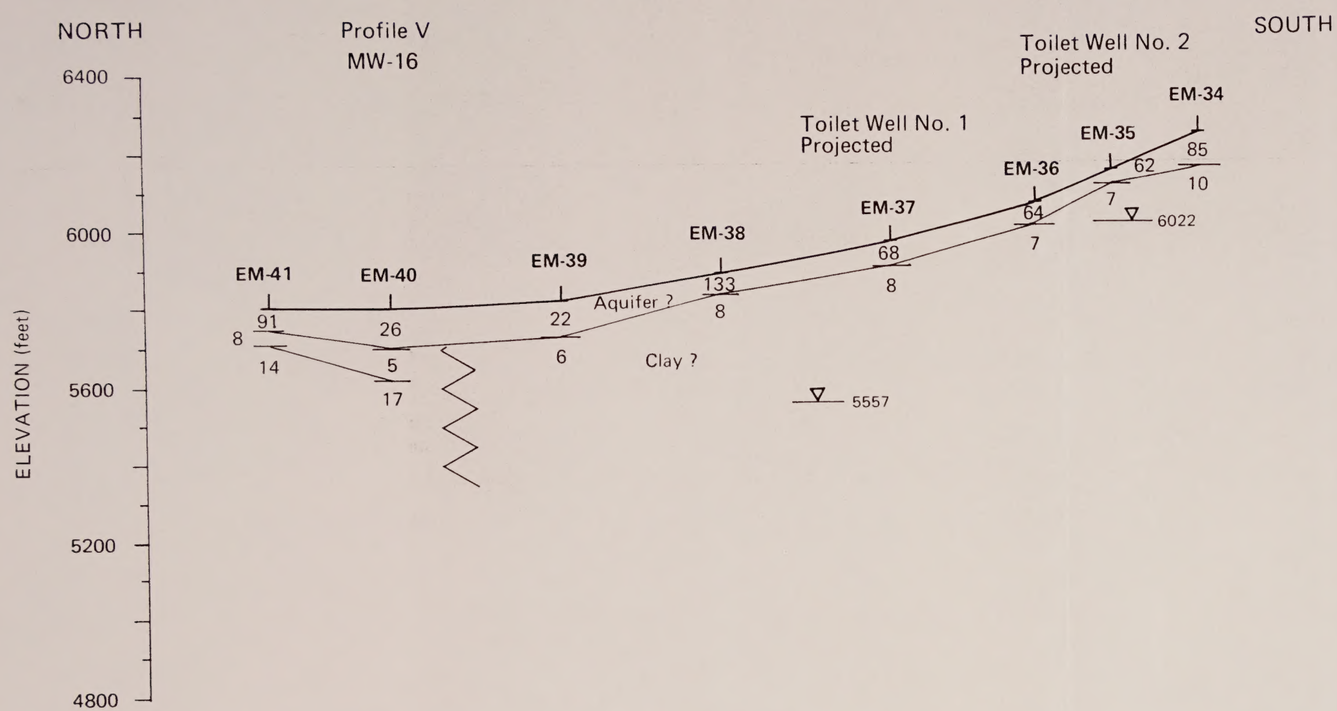
Unit Contacts Inferred between Sites Based on Similar TDEM Resistivities, Geologic Surface Mapping and Well Logs

Vertical Scale: 1" = 400'
Horizontal Scale: 1" = 4000'

Project No. 90270B	Thousand Springs Energy Park	TDEM PROFILE VIII	Figure A-1.10
Woodward-Clyde Consultants			

Bull Mountains

PROFILE IX



LEGEND

EM-34 TDEM Sounding Stations

▽ Measured Water Elevation

Resistivities in ohm-meters

Resistivities and Thicknesses
Interpreted from TDEM Sounding Data

Unit Contacts Inferred between Sites
Based on Similar TDEM Resistivities,
Geologic Surface Mapping and Well Logs

Vertical Scale: 1" = 400'
Horizontal Scale: 1" = 4000'

Project No. 90270B	Thousand Springs Energy Park	TDEM PROFILE IX	Figure A-1.11
Woodward-Clyde Consultants			

Bull Mountains

Federal Coal Ownership

... Coal Requested for Exchange

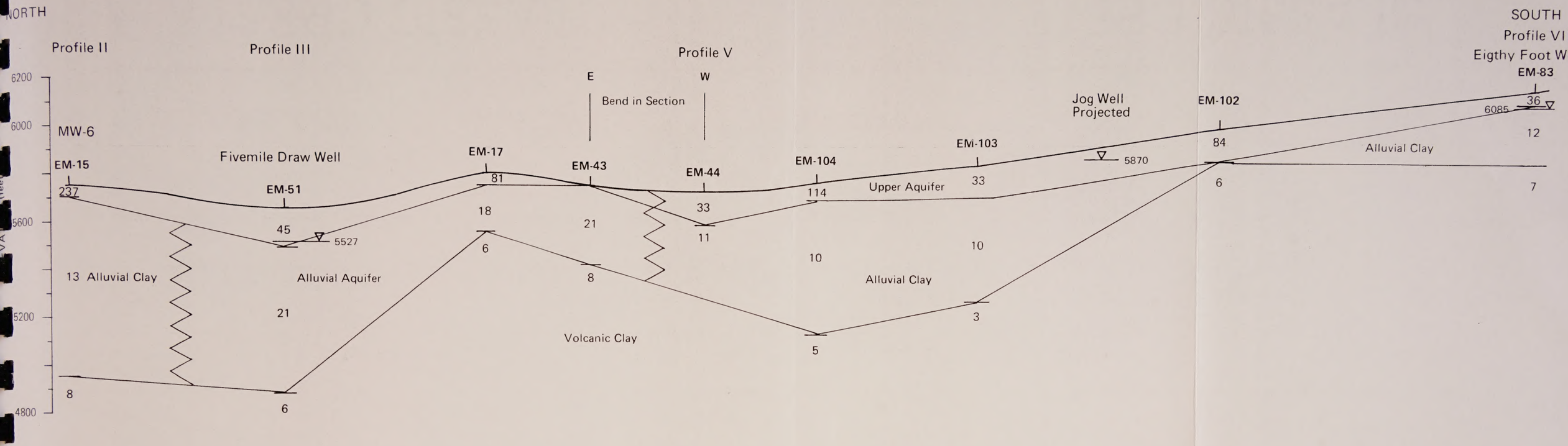
... Coal Ownership

... Lands Considered for Leasing

... Mineral Coal Ownership

... of Land Management Surface Ownership

PROFILE X



LEGEND

EM-15 TDEM Sounding Stations

▽ Measured Water Elevation

Resistivities in ohm-meters

Resistivities and Thicknesses
Interpreted from TDEM Sounding Data

Unit Contacts Inferred between Sites
Based on Similar TDEM Resistivities,
Geologic Surface Mapping and Well Logs

Vertical Scale: 1" = 400'
Horizontal Scale: 1" = 4000'

Project No. 90270B	Thousand Springs Energy Park	TDEM PROFILE X	Figure A-1.12
Woodward-Clyde Consultants			

Bull Mountains

Federal Coal Ownership

... Coal Requested for Exchange

... Coal Ownership

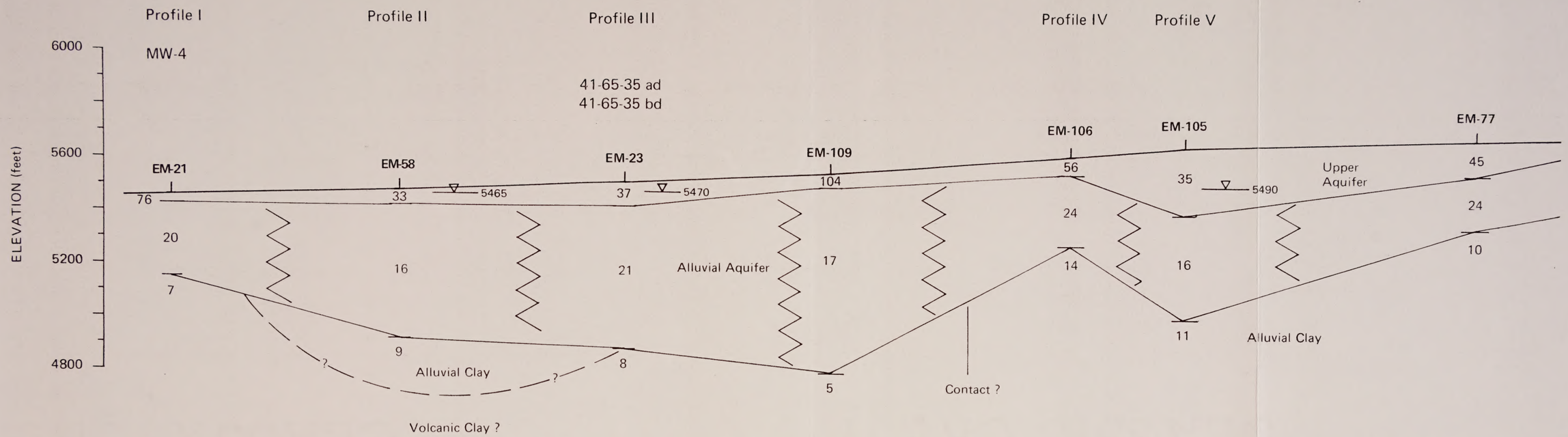
... Lands Considered for Leasing

... Mineral Coal Ownership

... of Land Management Surface Ownership

NORTH

PROFILE XI (North)



LEGEND

EM-21 TDEM Sounding Stations

∇ Measured Water Elevation

Resistivities in ohm-meters

Resistivities and Thicknesses
Interpreted from TDEM Sounding Data

Unit Contacts Inferred between Sites
Based on Similar TDEM Resistivities,
Geologic Surface Mapping and Well Logs

Vertical Scale: 1" = 400'
Horizontal Scale: 1" = 4000'

Project No. 90270B	Thousand Springs Energy Park	TDEM PROFILE XI (NORTH)	Figure A-1.13a
Woodward-Clyde Consultants			

Bull Mountains

...Federal Coal Ownership

...Coal Requested for Exchange

Coal Ownership

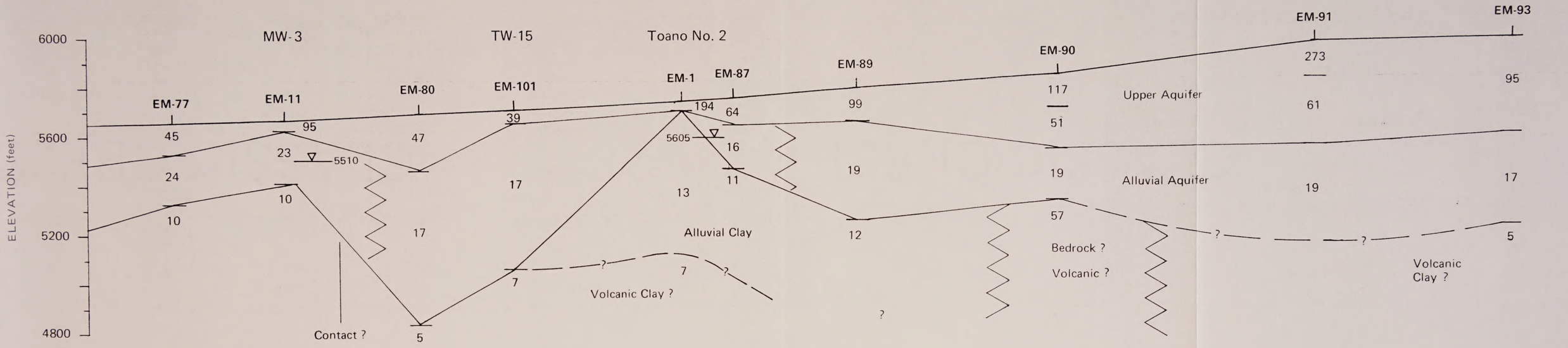
...Lands Considered for Leasing

...Minerals Coal Ownership

...of Land Management Surface Ownership

PROFILE XI (South)

SOUTH



LEGEND

EM-77 TDEM Sounding Stations

∇ Measured Water Elevation

Resistivities in ohm-meters

Resistivities and Thicknesses Interpreted from TDEM Sounding Data

Unit Contacts Inferred between Sites Based on Similar TDEM Resistivities, Geologic Surface Mapping and Well Logs

Vertical Scale: 1" = 400'
Horizontal Scale: 1" = 4000'

Project No. 90270B	Thousand Springs Energy Park	TDEM PROFILE XI (SOUTH)	Figure A-1.13b
Woodward-Clyde Consultants			

Bull Mountains

...Federal Coal Ownership

...n Coal Requested for Exchange

... Coal Ownership

...ional Lands Considered for Leasing

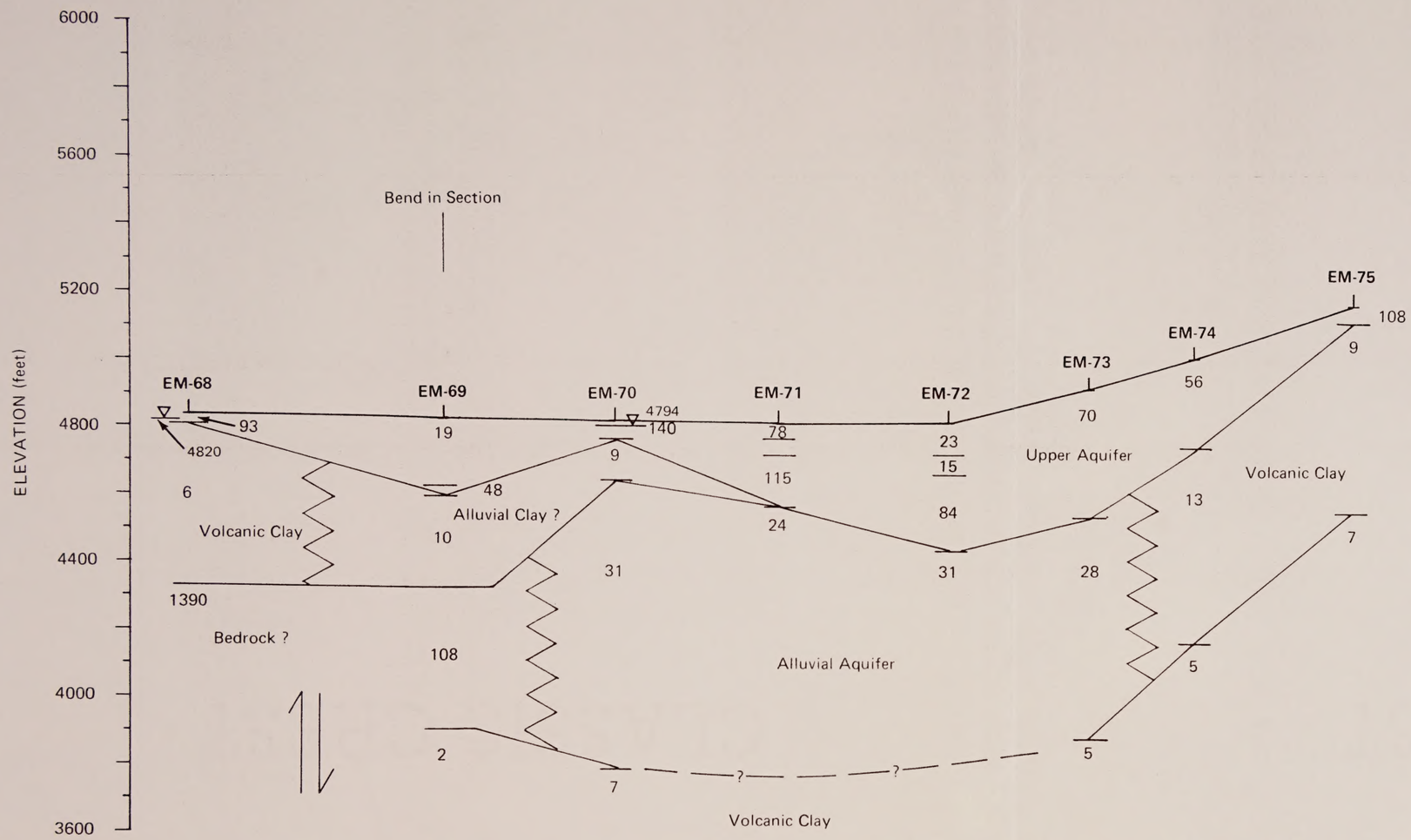
...lion Minerals Coal Ownership

...u of Land Management Surface Ownership

PROFILE XII (Montello Valley)

NORTHWEST

SOUTHEAST



LEGEND

EM-75 TDEM Sounding Stations

▽ Measured Water Elevation

Resistivities in ohm-meters

Resistivities and Thicknesses Interpreted from TDEM Sounding Data

Unit Contacts Inferred between Sites Based on Similar TDEM Resistivities, Geologic Surface Mapping and Well Logs

Vertical Scale: 1" = 400'
Horizontal Scale: 1" = 4000'

Project No. 90270B	Thousand Springs Energy Park	TDEM PROFILE XII (MONTELLO VALLEY)	Figure A-1.14
Woodward-Clyde Consultants			

Bull Mountains

...lated Area

Federal Coal Ownership

...h Coal Requested for Exchange

Coal Ownership

...ivate Lands Committed for Leasing

...ion Mineral Coal Ownership

...u of Land Management Surface Ownership

APPENDIX A-2

CORRELATION OF TDEM DATA WITH WCC MONITORING WELLS

TDEM soundings were conducted at each WCC monitoring well to correlate resistivities with borehole lithologic and geophysical logs. Geophysical methods used in most of the WCC wells include short and long normal resistivity (16 inch and 64 inch, respectively), natural gamma, spontaneous potential (SP), three arm caliper, temperature, and sonic. The resistivity logs provide the best correlation tool; natural gamma, SP, and caliper logs were also used for correlation. No attempt was made to correlate the temperature and sonic logs.

The TDEM method is best used to define the depth of the interface between a resistor overlying a conductor or geologically, a coarse-grained unit overlying a finer-grained deposit. Depths of units, chosen using the TDEM method, may vary from those recorded by well logs by up to 25 percent, with some sites showing much better agreement. Several factors might contribute to discrepancies between the two sets of data at a particular site:

- TDEM soundings measure the average resistivity of a large volume of material. Borehole resistivity measurements sense materials only within about 1 foot from the boring wall, thus providing a value representative of an adjacent and much smaller volume of material.

- The TDEM modeling inversion assumes a one-dimensional section; vertical changes in resistivity (layers) are analyzed, lateral changes are not. Thus, if lateral differences exist, they are

averaged by the program. This may result in significant errors in depth estimation. This would be particularly critical if the well is located in a small, geologically distinct area within but not representative of that covered by the TDEM sounding.

- Borehole resistivity values may not be corrected for drilling mud resistivities.

MW-1, EM-20

The inversion for TDEM Station EM-20 defines an average resistivity of about 19 ohm-m for the upper 900 feet. Well MW-1, drilled to 550 feet, maintains an average resistivity of 9-14 ohm-m to 400 feet. Resistivity values increase significantly to 50 ohm-m in the bottom 150 feet of the well. This area is underlain by large volumes of acidic volcanic rocks which may contribute to this large increase in resistivity.

Pump tests performed at this well resulted in poor yields.

MW-2, EM-13

TDEM Station EM-13 defines a 15 ohm-m layer to 175 feet overlying a 10 ohm-m layer. The 15 ohm-m unit is marginally within the range of potential aquifer values. Resistivity logs for MW-2 show a uniform 5-10 ohm-m unit from the beginning of logging at 125 feet to TD at 601 feet. Both methods suggest a clayey sequence with little water production as evidenced by relatively poor well yields in MW-2 and several other wells to the south and southwest. The water table measured in Well MW-2 at 180 feet coincides with the change in resistivity from 15 to 10 ohm-m measured by the TDEM method. Thus the TDEM sounding, at this site, probably identifies saturated conditions existing below the water table surface.

MW-3, EM-11

The inversion model for Sounding EM-11 results in three layers: an upper, 40-foot-thick, 95 ohm-m layer; a 23 ohm-m layer to 260 feet; and a lower, 10 ohm-m layer. Well MW-3 has good water production and is screened from 160 to 180 feet and 300 to 320 feet. The electric logs show high resistivity values from 50-150 feet. Finer-grained, 8-10 ohm-m materials extend through the rest of the 945-foot well. Lithologic logs for this well indicate a predominantly gravel and sand section to a depth of 750 feet. This is underlain by clay through the bottom 200 feet of the well. The high resistivity values measured between 50 and 150 feet are probably due to dry, sandy gravel. A decrease in resistivity below this depth is attributed to an increase in clay-sized material within the predominantly coarse sediments.

Comparison of the TDEM and downhole geophysical results indicates that while general correlation is good, some disparity does exist. The 23 ohm-m unit defined by the TDEM model is actually composed of several units of differing resistivity. However, the model does not reveal this stratigraphic complexity.

MW-4, EM-21

TDEM data suggest that a 76 ohm-m unit occurs within the upper 25 feet of section at Station EM-21. This is underlain by 20 ohm-m sediments to a depth of 300 feet. A 6 ohm-m unit comprises the rest of the sounding. Geophysical logs of Well MW-4 indicated a 20 ohm-m unit to a depth of 260 feet. This is underlain by a unit that gradually decreases in resistivity to 6 ohm-m at the total depth of 375 feet. Lithologic logs indicate the upper 260 feet consists primarily of sand.

MW-5, EM-6, and EM-8

The inversion model at EM-6 indicated an upper, 40-foot-thick, 173 ohm-m layer; a 6 ohm-m layer to 700 foot interpreted to be volcanic clay; and a lower layer with a resistivity of 52 ohm-m interpreted to be basement

rock. Well MW-5 encountered Paleozoic basement at 280 feet. This well site is located immediately west of a range-front fault which appears responsible for the shallow occurrence of bedrock at this location.

TDEM Sounding EM-8, a smaller loop placed within Sounding EM-6, indicated resistivity representative of basement rocks at a depth of 700 feet. This apparent disparity is probably the result of the location of the smaller loop over the eastern, downthrown side of the fault. In addition, lateral variations in resistivity values may be caused by the nearby fault and may complicate the model.

MW-6, EM-19

TDEM data at Station EM-19 indicate a 14 ohm-m unit occurs to 800 feet. This layer is underlain by a 43 ohm-m unit, interpreted to be Paleozoic bedrock. Lithologic logs for Well MW-6, however, report limestone at a depth of 50 feet, which is probably an error in interpretation. Instead, the material at that shallow depth is most likely a carbonate-enriched alluvial unit that has become indurated so that it appears to be bedrock. No description of possible aquifer material is reported in the remainder of the hole. The downhole resistivity survey for Well MW-6 encountered a 10-15 ohm-m unit throughout the majority of the hole. This is similar to the values reported from the TDEM model. In addition, a 30-50 ohm-m layer, probably bedrock, is present through the bottom 50 feet of the hole.

MW-12, EM-14

TDEM Sounding EM-14 indicates a 50-foot-thick section of high resistivity (172 ohm-m) material lying near the ground surface. This layer is underlain by about 1000 feet of coarse-grained (17-26 ohm-m) sediments. A low resistivity unit (4 ohm-m) interpreted to be volcanic clay is present below 1000 feet. Adjacent TDEM sites suggest the thickness of the coarse-grained unit decreases rapidly away from EM-14.

The lithologic and resistivity logs for Well MW-12 suggest stratigraphy that is similar to that defined by the TDEM model. Soil and loose, dry sand comprise the upper 40 feet of the hole. A mixture of fine to coarse sand and gravel of moderate resistivity is described to a depth of almost 400 feet. This is underlain by a 100-foot-thick clay unit which is represented on the borehole logs by a marked decrease in resistivity. A subsequent increase in resistivity is due to an increase in the amount of sand and gravel.

MW-14, EM-4, and EM-98

Soundings EM-4 and EM-98 are duplicate runs with nearly exact results. Inversion of these soundings indicate a coarse-grained, 23 ohm-m unit exists to a depth of about 700 feet. A thick, 12 ohm-m layer below 700 feet is interpreted as alluvial clay.

Well MW-14 consists of sand and gravel to its total depth of 508 feet. The downhole resistivity survey, conducted from 330 to 508 feet, reported values of about 20 ohm-m, consistent with the TDEM data.

MW-16, EM-40

Station EM-40, located near the head of Twentyone Mile Draw, identified a sequence of moderately low resistivity (17 ohm-m) material below 200 feet. This value is at the lowest end of the range considered indicative of aquifer materials.

Well MW-16, drilled to a depth of 600 feet, encountered predominantly fine-grained sediments throughout its entire depth. In addition, no water was present in the hole. This implies that the 17 ohm-m resistivity value suggested by the TDEM model is indicative of nonaquifer materials at this location.

APPENDIX B
SURFACE WATER RECORDS AND ESTIMATES

CONTENTS

Tables

B-1 PRECIPITATION, STREAMFLOW, AND RESERVOIR STAGE DATA COLLECTED BY CHILTON, 1982-1988

B-2 ANNUAL PRECIPITATION AT CONTACT, MONTELLO, AND WELLS NOAA MONITORING STATIONS, 1949-1983

B-3 MONTHLY PRECIPITATION AT CONTACT, MONTELLO, AND WELLS NOAA MONITORING STATIONS, 1985-1988

B-4 WATERSHED AREAS BY ELEVATION ZONES WITHIN THIESSEN POLYGONS, AS USED IN STREAMFLOW GENERATION MODEL - THOUSAND SPRINGS BASIN

B-5 ESTIMATED AVERAGE ANNUAL PRECIPITATION AND CONTRIBUTIONS TO GROUNDWATER RECHARGE BASED ON MAXEY AND EAKIN METHOD BY ELEVATION ZONES AND THIESSEN POLYGON AREAS, THOUSAND SPRINGS BASIN ABOVE MONTELLO STREAMFLOW GAGING STATION

B-6 AVERAGE MONTHLY STREAMFLOWS AT WILKINS, SHORES, AND MONTELLO USGS GAGING STATIONS, THOUSAND SPRINGS CREEK, 1985-1988

Figures

B-1a through B-11 - CORRELATION OF CONTACT AND WELLS, AND MONTELLO AND WELLS HISTORICAL MONTHLY PRECIPITATION, JANUARY THROUGH DECEMBER, RESPECTIVELY

Table B-1. PRECIPITATION, STREAMFLOW, AND RESERVOIR STAGE DATA COLLECTED BY CHILTON, 1982-1988

					1982					
	18-Feb	19-Feb	23-Feb	24-Feb	2-Mar	9-Mar	16-Mar	19-Mar	23-Mar	29-Mar
PRECIPITATION STATION										
Wilkins					0.10	0.10				
Five Mile Ranch					0.10	0.10			2.40	0.10
Lower Eccles						0.20			2.20	0.20
Twelve Mile Ranch						0.20	1.20	1.10		
HD Summit										
Moor Summit										
Pequop										
Pequop Summit										
Rocky Point										
Cobre										
STREAMFLOW STATION										
Wilkins/Wilkins Canal	65.00	2.00	95.00		46.00	22.00		12.00		52.00
WC Lane/Beaver	70.00		77.00		38.00	21.00		27.00		63.00
Toano Draw	5.00		0.00		0.00	0.00		0.00		0.00
Narrows	175.00		51.00		28.00	12.00		21.00		43.00
Rock Springs Creek	100.00		0.00		0.40	0.00		0.00		0.00
Eccles Narrows			22.00		20.00	11.00		28.00		38.00
Twenty-One Mile Jct				9.00		10.00		10.00		14.00
Lower Schoolhouse										
Crittenden Creek		4.00		0.00		0.00		0.00		
Rocky Ford		8.00		4.00		4.00		5.00		
Highway 30		2.00		0.60		0.60				
RESERVOIR STATION										
Twenty-One Mile				5189.40	5189.45	5189.35	5189.53	5189.85		
Dake				4757.30		4757.30				

Table B-1. PRECIPITATION, STREAMFLOW, AND RESERVOIR STAGE DATA COLLECTED BY CHILTON, 1982-1988 (continued)

					1982					
	5-Apr	6-Apr	12-Apr	19-Apr	4-May	5-May	6-May	21-May	4-Jun	17-Jun
PRECIPITATION STATION										
Wilkins	0.10		0.30				0.10	0.50	0.60	0.30
Five Mile Ranch	0.20		0.50				0.10	0.30	0.30	0.20
Lower Eccles	0.20		0.50	0.00			0.10	0.60	0.20	0.20
Twelve Mile Ranch		0.60	0.40	0.00			0.10	0.30	0.50	0.10
HD Summit										
Moor Summit										
Pequop										
Pequop Summit										
Rocky Point										
Cobre										
STREAMFLOW STATION										
Wilkins/Wilkins Canal	15.00			54.00		91.00		46.50	26.00	14.15
WC Lane/Beaver	51.00		107.50	64.00		88.00		47.50	24.00	12.27
Toano Draw	0.00		0.00	0.00		0.00		0.00	0.00	0.00
Narrows	26.00		37.00	41.00		60.00		34.00	17.00	8.30
Rock Springs Creek	0.00		0.00	0.00		0.00		0.75	0.25	0.00
Eccles Narrows	18.00		27.00	37.00		39.00		26.00	15.00	2.80
Twenty-One Mile Jct	9.00		12.00	10.00		29.00		21.00	15.00	10.96
Lower Schoolhouse										6.03
Crittenden Creek		0.00	0.00	0.00	0.00			2.00	6.00	0.00
Rocky Ford		5.00	4.00	3.00	4.00			4.00	4.00	2.14
Highway 30		0.85	0.70	0.50	1.00			0.50		0.25
RESERVOIR STATION										
Twenty-One Mile	5190.55		5190.65	5191.57		5191.88		5191.70	5191.45	5190.65
Dake		4757.60	4757.60	4757.77		4757.01		4757.06		4756.04

Table B-1. PRECIPITATION, STREAMFLOW, AND RESERVOIR STAGE DATA COLLECTED BY CHILTON, 1982-1988 (continued)

						1982							
	7-Jul	20-Jul	25-Jul	9-Aug	20-Aug	21-Sep	22-Sep	28-Sep	22-Oct	22-Nov	23-Nov	17-Dec	18-Dec
PRECIPITATION STATION													
Wilkins	0.90	0.10			0.75	2.45		1.00	0.50	0.80		0.90	
Five Mile Ranch	1.10	0.10			0.60	2.30		1.00	0.40	0.80		1.00	
Lower Eccles	1.10	0.40			1.00	3.00		0.90	0.50		0.90	1.10	
Twelve Mile Ranch	0.50	0.60			0.70	3.10		1.00	0.50		1.40		1.30
HD Summit													
Moor Summit													
Pequop													
Pequop Summit													
Rocky Point													
Cobre													
STREAMFLOW STATION													
Wilkins/Wilkins Canal	4.48	1.25	0.00	0.00	0.00		0.50	0.70	1.06	1.50		1.50	
WC Lane/Beaver	3.05	0.00		0.00	0.54		0.93	1.49	1.40	1.71		2.04	
Toano Draw	0.00	0.00			0.00		0.00	0.00	0.00	0.00		0.00	
Narrows	0.85	0.75			0.50		1.50	1.27	0.70	1.50		1.50	
Rock Springs Creek	0.00	0.00			0.00		0.00	0.00	0.00	0.00		0.00	
Eccles Narrows	0.24	0.25			0.01		0.25	0.50	0.06		0.00	1.00	
Twenty-One Mile Jct	11.30	8.81			7.80		10.17	9.40	7.73		7.11		6.94
Lower Schoolhouse	3.71	0.25			3.84		3.80	5.72	4.56		4.00		3.00
Crittenden Creek	1.36	2.03			0.00		0.44	0.00	0.00		0.00		0.00
Rocky Ford	2.00	1.33			1.00		1.00	2.46	2.83		2.37		1.65
Highway 30	0.25				0.00		0.00	0.05			0.03		0.06
RESERVOIR STATION													
Twenty-One Mile	5189.05	5188.06			5185.74	5183.60		5183.25	5182.07		5180.84	5179.85	
Dake	4755.53				4754.54	4754.45		4754.64			4755.29		4755.56

Table B-1. PRECIPITATION, STREAMFLOW, AND RESERVOIR STAGE DATA COLLECTED BY CHILTON, 1982-1988 (continued)

						1983						
	24-Jan	15-Feb	24-Feb	2-Mar	7-Mar	15-Mar	17-Mar	22-Mar	30-Mar	7-Apr	14-Apr	15-Apr
PRECIPITATION STATION												
Wilkins	0.80	1.20	0.00	0.60	0.00		0.50		0.90	0.20		0.10
Five Mile Ranch	0.90	1.00			1.00	0.20		0.30	0.30	0.30	0.20	
Lower Eccles	0.80	0.80	0.00	0.40	0.40	0.30		0.10	0.40	0.60	0.00	
Twelve Mile Ranch	0.90	1.10	0.00	0.50	0.20	0.40		0.30	0.50	0.40	0.10	
HD Summit			2.00	1.00	0.10		0.20	0.10	0.90	0.70	0.20	
Moor Summit		1.40	0.20	0.60	0.20	0.80			0.60	1.30	0.20	
Pequop											2.40	
Pequop Summit												
Rocky Point												
Cobre												
STREAMFLOW STATION												
Wilkins/Wilkins Canal	3.00	1.00	55.95	189.30	29.54	94.00		25.79	32.08	23.36		23.16
WC Lane/Beaver	1.56	1.60	179.92	320.39	19.36	97.84		31.27	27.83	28.91		33.44
Toano Draw	0.00	5.00				0.00		0.00	0.00	0.00		0.00
Narrows	2.00	13.31			40.74	133.63		31.30	24.88	31.26	27.87	
Rock Springs Creek	0.00	3.24	10.00	5.00	0.00	0.00		0.00	0.00	0.00	0.00	
Eccles Narrows	1.00	48.44	180.00	367.00	38.85	81.34		33.40	21.69	31.35	28.08	
Twenty-One Mile Jct	6.78	7.00	17.50	94.15	86.46	37.79		45.72	29.50	34.08	28.96	
Lower Schoolhouse	2.00	10.68	30.00						30.05	34.03	27.82	
Crittenden Creek	0.00	0.06	0.25	0.00	0.00	0.00		0.00	0.00	0.00	0.00	
Rocky Ford	3.00	8.72	9.68	32.00	51.00	20.55		34.85	22.00	26.43	20.76	
Highway 30			0.25	1.00	1.00	2.00		2.00	2.00	1.00	1.50	
RESERVOIR STATION												
Twenty-One Mile	5180.44	5180.07	5189.45	5193.15	5192.45	5192.00		5191.95	5191.50		5191.58	
Dake		4756.53	4761.60	4761.95	4762.06	4762.10		4761.90	4761.80		4761.68	

Table B-1. PRECIPITATION, STREAMFLOW, AND RESERVOIR STAGE DATA COLLECTED BY CHILTON, 1982-1988 (continued)

						1983					
	2-May	16-May	17-May	1-Jun	16-Jun	17-Jun	1-Jul	14-Jul	15-Aug	1-Sep	23-Sep
PRECIPITATION STATION											
Wilkins	2.70	0.30		0.40	1.15		0.00	0.20	0.60	0.40	
Five Mile Ranch	2.30	0.40		0.30		1.50	0.00	0.30	1.40		0.50
Lower Eccles	2.00	0.40		0.40		1.30	0.20	0.20	1.40		1.20
Twelve Mile Ranch	1.30	0.50		0.20		2.30	0.00	0.30	2.40		1.50
HD Summit	2.30			0.10	1.20			0.20	0.90		
Moor Summit	1.90	0.70		0.40		1.10	0.10	0.30	1.30		1.10
Pequop	1.20	0.90		0.40		1.80	0.00		1.80		
Pequop Summit											
Rocky Point									1.20		1.20
Cobre											
STREAMFLOW STATION											
Wilkins/Wilkins Canal	98.34		37.69	54.64	19.54		6.92	3.22		1.07	1.00
WC Lane/Beaver	109.38		45.11	56.96	17.89		4.47	1.98		0.84	0.66
Toano Draw	0.00		0.00		0.00		0.00	0.00		0.00	0.00
Narrows	103.94		44.57	57.78		14.96	3.50	0.90	0.50		0.11
Rock Springs Creek	6.50		5.00	5.00		0.20	0.00	0.00	0.00		0.00
Eccles Narrows	97.34	46.09		50.25		15.86	1.00	0.50	0.02		0.04
Twenty-One Mile Jct	89.62	57.79		41.70		28.03	19.60	8.27	7.68		5.69
Lower Schoolhouse						29.17	16.74	7.89	6.52		2.48
Crittenden Creek	0.00	0.00		2.82		2.00	0.00	0.00	1.58		0.00
Rocky Ford	55.16	42.59		20.04		16.64	6.18	6.08	5.20		3.12
Highway 30	1.50	1.50		1.50		2.00	1.50	1.50	1.00		1.50
RESERVOIR STATION											
Twenty-One Mile	5192.60	5192.15		5191.90		5191.53	5190.00	5188.65	5186.80		5184.75
Dake	4761.65	4761.85		4762.20		4761.85	4761.40	4760.95	4759.85		4758.90

Table B-1. PRECIPITATION, STREAMFLOW, AND RESERVOIR STAGE DATA COLLECTED BY CHILTON, 1982-1988 (continued)

						1986						
	18-Feb	24-Feb	3-Mar	10-Mar	17-Mar	24-Mar	31-Mar	7-Apr	18-Apr	24-Apr	7-May	5-Jun
PRECIPITATION STATION												
Wilkins	1.40	0.70		0.15	0.35	0.00	0.00	0.20	0.70		0.90	0.45
Five Mile Ranch	1.00	0.60	0.00	0.10	0.50	0.00	0.00	0.50	1.10		1.20	0.20
Lower Eccles	0.70	0.80		0.20	0.70	0.00	0.00	0.90	1.30		0.80	0.30
Twelve Mile Ranch	1.20	0.50	0.00	0.15	0.60	0.00	0.00	0.40	1.75		1.60	0.40
HD Summit	1.90	1.00		0.30	0.90	0.00	0.00	0.30	1.10		1.40	0.70
Moor Summit	1.40	0.60	0.10	0.10	1.30	0.10	0.00	0.50	2.05	0.10	1.60	0.00
Pequop												
Pequop Summit			0.10	0.30		1.60	0.00	0.30	1.60	0.95	2.40	0.20
Rocky Point												
Cobre					1.55	0.00	0.20	0.25	1.65		1.70	0.60
STREAMFLOW STATION												
Wilkins/Wilkins Canal	300.00	150.80	72.70									
WC Lane/Beaver	63.50	174.10	74.70	59.36	40.60	26.14	37.38	34.50	26.88		19.69	6.11
Toano Draw			0.00	0.00	0.00	0.00	0.00	0.00	0.00		0.00	0.00
Narrows												
Rock Springs Creek	12.90	0.00	0.00	0.01	0.25	0.00	0.10	3.10	2.00		2.00	0.25
Eccles Narrows	430.00	63.10	66.60	66.20	47.78	16.80	19.49	34.02	21.77		28.58	0.05
Twenty-One Mile Jct	16.80	9.00	73.50	55.68	51.52	26.18	20.33	29.97	32.64		19.25	11.73
Lower Schoolhouse		10.20				25.72	18.88	24.98	27.99		14.63	1.60
Crittenden Creek	0.50	0.00	0.00	0.00	0.00	0.00	0.00	0.00	0.00		0.00	3.25
Rocky Ford	74.00	11.30	65.80	48.20	48.60	23.15	15.88	22.48	26.80		12.49	5.30
Highway 30	1.50	1.50	1.50	26.10	43.60	29.45	15.59	13.67				
RESERVOIR STATION												
Twenty-One Mile	5185.90	5190.60	5192.40	5192.45	5192.10	5191.55	5191.45	5191.70	5191.70		5191.45	5190.55
Dake	4765.80	4766.80	4767.60	4768.50	4768.75	4768.60	4768.40	4768.42	4768.60		4768.30	4767.85

Table B-1. PRECIPITATION, STREAMFLOW, AND RESERVOIR STAGE DATA COLLECTED BY CHILTON, 1982-1988 (continued)

			1986			
	7-Jul	31-Jul	26-Aug	6-Oct	3-Nov	1-Dec
PRECIPITATION STATION						
Wilkins	0.40	0.20	0.25	1.65	0.85	0.15
Five Mile Ranch	0.40	1.40	1.35	1.60	0.85	0.30
Lower Eccles	0.35	1.00	0.45	1.45	0.85	0.20
Twelve Mile Ranch	0.15	1.05	0.35	1.55	0.65	0.20
HD Summit	0.40	0.20	0.20	2.00	1.05	0.25
Moor Summit	0.20	0.70	0.80	1.80	0.70	0.30
Pequop						
Pequop Summit	0.10	0.30	0.50	1.55	0.70	0.30
Rocky Point	0.10	0.40	0.10	0.75		
Cobre	0.20	0.60	0.15	1.45	0.75	
STREAMFLOW STATION						
Wilkins/Wilkins Canal						
WC Lane/Beaver	2.63	2.63	1.09	1.27	1.79	3.52
Toano Draw	0.00	0.00	0.00	0.00	0.00	0.00
Narrows						
Rock Springs Creek	0.01	0.00	0.00	0.00	0.00	0.00
Eccles Narrows	0.01	0.00	0.03	0.40	0.05	0.04
Twenty-One Mile Jct	9.66	9.88	8.44	7.61	6.12	3.98
Lower Schoolhouse	9.29	6.68	0.49	3.11	3.29	3.00
Crittenden Creek	0.90	0.00	0.00	0.00	0.00	0.00
Rocky Ford	9.61	7.62	4.36	4.02	3.70	3.21
Highway 30						
RESERVOIR STATION						
Twenty-One Mile	5188.10	5186.50	5184.40	5182.80	5182.10	5181.70
Dake	4766.90	4766.40	4765.60	4764.90	4764.70	4764.60

Table B-1. PRECIPITATION, STREAMFLOW, AND RESERVOIR STAGE DATA COLLECTED BY CHILTON, 1982-1988 (continued)

					1987					
	7-Jan	3-Feb	17-Feb	4-Mar	17-Mar	6-Apr	27-Apr	1-Jun	2-Jul	31-Jul
PRECIPITATION STATION										
Wilkins	0.45	0.40	0.25	0.40	1.35	0.40	0.10	2.85	0.55	0.25
Five Mile Ranch	0.30	0.30	0.35	0.35	0.90	0.35	0.05	2.30	0.55	
Lower Eccles	0.25	0.20	0.10	0.45	0.80	0.60		3.25		1.25
Twelve Mile Ranch	0.30	0.15	0.60	0.55	0.85	0.50	0.00	2.05	0.80	1.15
HD Summit	0.85	0.75	0.35	0.50	1.50	0.85	0.05	3.25	1.05	0.50
Moor Summit	0.80	0.35	0.90	1.20	0.95	0.90	0.00	3.35	1.25	1.15
Pequop										
Pequop Summit	1.20	0.60	0.80	1.05	1.25	0.60	0.05	4.00	1.95	1.25
Rocky Point										
Cobre	0.50	0.20	0.45	0.75	0.55	0.30	0.00	2.95	0.55	1.10
STREAMFLOW STATION										
Wilkins/Wilkins Canal										
WC Lane/Beaver	3.73	2.05	2.81	2.57	3.51	2.65	1.84	1.85	0.61	0.42
Toano Draw	0.00	0.00	0.00	0.00	0.00	0.00	0.00	0.00	0.00	0.00
Narrows										
Rock Springs Creek	0.00	0.00	0.40	0.10	0.00	0.00	0.00	0.04	0.08	0.02
Eccles Narrows				0.10	0.00	0.01	0.04	0.05	0.05	0.09
Twenty-One Mile Jct	3.00	5.00	4.52	5.19	5.27	5.48	4.59	4.82	5.10	2.98
Lower Schoolhouse	2.00	4.00	6.32	5.50	6.62	5.23	4.64	2.01	1.87	1.44
Crittenden Creek	0.00	0.00	0.00	0.00	0.00	0.00	0.00	2.12	0.00	2.06
Rocky Ford	1.93	3.36	4.89	6.96	7.28	6.08	5.77	5.66	1.54	4.03
Highway 30										
RESERVOIR STATION										
Twenty-One Mile	5181.60	5181.20	5180.70	5180.55	5180.70	5180.20	5177.40	5179.10	5177.65	5176.85
Dake	4764.50	4764.50	4764.70	4764.75	4765.30	4765.80	4765.80	4765.70	4765.00	4764.35

Table B-1. PRECIPITATION, STREAMFLOW, AND RESERVOIR STAGE DATA COLLECTED BY CHILTON, 1982-1988 (continued)

		1987		
	28-Aug	2-Oct	30-Oct	1-Dec
PRECIPITATION STATION				
Wilkins	0.10	0.25	0.70	1.20
Five Mile Ranch		0.00	0.65	1.30
Lower Eccles	0.15	0.00	0.75	1.10
Twelve Mile Ranch	1.00	0.00	0.95	1.85
HD Summit	0.05	0.00	0.75	1.45
Moor Summit	0.85	0.00	0.70	2.05
Pequop				
Pequop Summit	0.35		1.70	2.05
Rocky Point				
Cobre	0.90	0.00	1.40	1.60
STREAMFLOW STATION				
Wilkins/Wilkins Canal				
WC Lane/Beaver	0.48	0.39	1.24	1.76
Toano Draw	0.00	0.00	0.00	0.00
Narrows				
Rock Springs Creek	0.00	0.00	0.00	0.00
Eccles Narrows	0.01	0.01	0.02	0.01
Twenty-One Mile Jct	6.08	3.82	6.22	5.72
Lower Schoolhouse	0.37	3.52	6.37	5.64
Crittenden Creek	0.00	0.00	0.00	0.00
Rocky Ford	3.56	1.29	3.18	5.33
Highway 30				
RESERVIOR STATION				
Twenty-One Mile	5175.30	5173.80	5172.20	5171.60
Dake	4763.70	4763.20	4762.95	4763.05

Table B-1. PRECIPITATION, STREAMFLOW, AND RESERVOIR STAGE DATA COLLECTED BY CHILTON, 1982-1988 (concluded)

				1988						
	1-Feb	17-Feb	1-Mar	1-Apr	29-Apr	2-Jun	30-Jun	1-Aug	30-Aug	3-Oct
PRECIPITATION STATION										
Wilkins	1.95	0.10	0.15	0.40	0.75	1.50	0.30	0.35	0.15	0.05
Five Mile Ranch	2.05	0.15	0.15	0.55	0.60	1.05	0.90	0.15	0.20	0.00
Lower Eccles	2.65	0.25	0.15	0.75	0.45	1.40	1.35	0.15	0.30	0.00
Twelve Mile Ranch	2.15	0.10	0.35	0.60	0.65	1.50	0.75	0.15	0.15	0.04
HD Summit	2.05	0.25	0.15		0.70	1.25	0.15	0.05	0.00	0.10
Moor Summit	2.05	0.15	0.15	0.55	0.65	2.40	0.55	0.00	0.65	0.20
Pequop										
Pequop Summit	2.05	0.20	0.15	0.70	1.15	2.50	0.90	0.10	0.65	0.00
Rocky Point										
Cobre	1.85	0.15	0.30	0.45	0.45	0.95	0.75	0.30	0.95	0.00
STREAMFLOW STATION										
Wilkins/Wilkins Canal										
WC Lane/Beaver	0.90	2.30	2.19	1.78	1.77	1.14	0.57	0.54	0.50	0.61
Toano Draw	0.00	0.00	0.00	0.00	0.00	0.00	0.00	0.00	0.00	0.00
Narrows										
Rock Springs Creek	0.00	0.07	0.00	0.00	0.00	0.00	0.00	0.00	0.00	0.00
Eccles Narrows	0.00	1.00	0.10	0.02	0.03	0.02	0.20	0.00	0.00	0.00
Twenty-One Mile Jct	6.24	6.89	7.09	4.85	4.20	5.15	3.84	4.83	4.46	2.25
Lower Schoolhouse	2.00	5.15	6.37	5.25	0.44	0.92	0.17	0.00	0.00	0.00
Crittenden Creek	0.00	0.00	0.00	0.00	0.00	0.75	0.00	2.71	0.00	2.62
Rocky Ford	5.11	6.27	6.81	6.51	4.98	1.79	4.54	3.57	1.17	2.93
Highway 30										
RESERVOIR STATION										
Twenty-One Mile	5170.00	5170.50	5170.70	5170.15	5169.40	5168.00	5166.80	5164.80	5162.40	5156.50
Dake	4763.10	4763.45	4763.60	4764.30	4764.40	4763.90	4763.30	4762.50	4762.00	4761.30

Table B-2. ANNUAL PRECIPITATION AT CONTACT, MONTELLO, AND WELLS NOAA MONITORING STATIONS 1949-1983

Year	Annual Precipitation (inches)		
	Contact	Montello	Wells
1949	6.69	6.17	9.87
1950	8.13	--	10.85
1951	10.04	6.86	7.62
1952	7.06	6.01	9.43
1953	8.37	4.90	8.44
1954	5.37	5.26	6.69
1955	11.84	5.48	11.77
1956	9.51	5.97	8.90
1957	11.79	10.08	10.32
1958	7.40	4.91	7.58
1959	9.30	5.61	7.20
1960	7.68	6.22	8.83
1961	11.07	8.44	6.71
1962	10.06	7.27	10.16
1963	14.53	11.58	14.59
1964	11.16	7.02	10.63
1965	12.07	7.75	11.37
1966	5.96	3.18	6.73
1967	11.02	7.31	10.35
1968	11.30	10.42	11.92
1969	9.66	8.83	10.58
1970	10.73	7.88	13.46
1971	16.24	10.50	14.17
1972	11.61	8.26	8.94
1973	11.69	9.26	10.68
1974	8.08	4.21	5.53
1975	12.04	10.51	12.90
1976	8.86	6.75	8.58
1977	8.94	9.95	8.59
1978	8.78	7.01	9.15
1979	9.33	8.34	9.13
1980	12.49	11.03	15.51
1981	9.44	6.00	9.71
1982	12.67	11.79	15.53
1983	15.01	10.85	20.67
Average	10.17	7.69	10.80

Compiled by Woodward-Clyde Consultants from NOAA (1949-1983) data.

Table B-3. MONTHLY PRECIPITATION AT CONTACT, MONTELLO, AND WELLS NOAA MONITORING STATIONS, 1985-1988[1]

Year	Month	Total Monthly Precipitation (inches) Contact	Montello	Wells
1985	March	(1.06)	(0.76)	1.60
	April	0.09	0.00	0.14
	May	1.26	0.58	0.75
	June	0.49	0.28	0.50
	July	0.90	(0.71)	0.62
	August	0.00	0.00	0.04
	September	(0.93)	0.70	1.13
	October	0.42	0.47	0.40
	November	1.28	(0.77)	1.22
	December	0.52	(0.45)	0.65
1986	January	0.33	0.22	0.38
	February	1.62	1.57	1.74
	March	0.78	(0.47)	0.93
	April	(1.62)	1.22	2.51
	May	0.90	0.72	0.44
	June	0.20	0.19	0.22
	July	0.38	1.06	0.80
	August	(0.41)	(0.52)	0.19
	September	1.30	0.69	1.91
	October	0.38	0.74	0.29
	November	(0.44)	0.00	0.25
	December	(0.28)	0.05	0.06
1987	January	0.56	(0.33)	0.43
	February	(0.76)	0.28	1.45
	March	1.26	0.81	0.82
	April	0.03	0.14	0.13
	May	2.34	1.99	1.98
	June	(0.96)	0.61	0.69
	July	(0.43)	1.14	0.21
	August	0.09	0.14	0.00
	September	(0.23)	0.00	0.00
	October	(0.14)	1.53	0.16
	November	(1.13)	1.48	1.71
	December	(1.34)	0.88	1.64
1988	January	(0.98)	0.09	1.25
	February	(0.21)	0.00	0.02
	March	(0.44)	0.15	0.31
	April	(0.49)	0.39	0.28
	May	(1.21)	0.69	0.85

Woodward-Clyde Consultants computed values in ( ) based on correlation analysis (Figure B-1) of data provided by the National Oceanic and Atmospheric Administration, 1940-1988 Climatological Data for Nevada.

[1] Period selected to coincide with period for which streamflow records are available from USGS Wilkins, Shores, and Montello gaging stations, and as summarized in Table B-6.

Table B-4. WATERSHED AREAS BY ELEVATION ZONES WITHIN THIESSEN POLYGONS, AS USED IN STREAMFLOW GENERATION MODEL, THOUSAND SPRINGS BASIN

Elevation Zone (Meters)	Mid-Zone Elevation (Feet)	Above Wilkins Gaging Station Within Thiessen Polygons (Square Miles)			Above Shores Gaging Station Within Thiessen Polygons (Square Miles)			Above Proposed Crittenden Gaging Station Within Thiessen Polygons (Square Miles)			Above Montello Gaging Station Within Thiessen Polygons (Square Miles)		
		Contact	Montello	Wells	Contact	Montello	Wells	Contact	Montello	Wells	Contact	Montello	Wells
1400-1520	4790	0.00	0.00	0.00	0.00	0.00		0.00	0.39	0.00	0.00	79.78	0.00
1520-1640	5184	0.00	0.00	0.00	4.27	0.35		23.93	39.85	0.00	23.93	134.91	0.00
1640-1760	5578	0.23	0.00	0.00	23.36	83.65		100.74	179.69	22.03	100.74	230.59	22.03
1760-1880	5971	9.00	0.00	11.72	27.24	89.07		116.04	186.69	64.34	116.04	239.02	64.34
1880-2000	6365	0.00	0.00	25.32	8.30	33.17		51.13	93.15	59.06	51.13	129.94	59.06
2000-2120	6759	0.00	0.00	10.68	3.84	11.81		27.56	40.95	23.58	27.56	66.91	23.58
2120-2240	7153	0.00	0.00	7.41	1.32	5.38		12.72	16.70	13.31	12.72	33.63	13.31
2240-2360	7546	0.00	0.00	1.73	0.07	2.17		3.94	4.13	4.10	3.94	9.10	4.10
2360-2480	7940	0.00	0.00	1.27	0.00	0.50		1.92	0.50	1.80	1.92	1.41	1.80
2480-2600	8334	0.00	0.00	0.51	0.00	0.00		0.62	0.00	0.51	0.62	0.00	0.51
2600-2720	8727	0.00	0.00	0.00	0.00	0.00		0.11	0.00	0.00	0.11	0.00	0.00
Total		9.23	0.00	58.64	68.40	226.10		338.71	562.06	188.73	338.71	925.29	188.73

Total areas above various stations: Wilkins 67.87 sq. mi.; Shores 483.23 sq. mi.; Crittenden 1089.49 sq. mi.; Montello 1452.73 sq. mi.

Source: Woodward-Clyde Consultants

Table B-5. ESTIMATED AVERAGE ANNUAL PRECIPITATION AND CONTRIBUTIONS TO GROUNDWATER RECHARGE BASED ON MAXEY AND EAKIN METHOD BY ELEVATION ZONES AND THIESSEN POLYGON AREAS - THOUSAND SPRINGS BASIN ABOVE MONTELLO STREAMFLOW GAGING STATION

Elevation Zone (Meters)	Zone Mid-Elevation (Feet)	Contact Polygon				Montello Polygon				Wells Polygon			
		Area (Sq. Mi.)	Mean Precip. (In./Yr)	Total Precip. (AF/Yr)	Total Rechg (AF/Yr)	Area (Sq. Mi.)	Mean[1] Precip. (In./Yr)	Total Precip. (AF/Yr)	Total Rechg (AF/Yr)[2]	Area (Sq. Mi.)	Mean Precip. (In./Yr)	Total Precip (AF/Yr)	Total Rechg (AF/Yr)
1400	4790	--	--	--	--	79.78	7.31	31,104	0	--	--	--	--
1520	5184	23.93	9.39	11,984	281	134.91	8.99	64,685	1295	--	--	--	--
1640	5578	100.74	11.08	59,531	2257	230.59	10.68	131,344	4427	22.03	10.06	11,820	341
1760	5971	116.04	12.77	79,031	4580	239.02	12.37	157,689	8414	64.34	11.75	40,320	1819
1880	6365	51.13	14.45	39,404	3327	129.94	14.05	97,368	7554	59.06	13.43	42,303	2866
2000	6759	27.56	16.14	23,724	2793	66.91	15.74	56,169	6138	23.58	15.12	19,015	1836
2120	7153	12.72	17.83	12,096	1920	33.63	17.43	31,262	4627	13.31	16.81	11,933	1590
2240	7546	3.94	19.51	4100	853	9.10	19.11	9275	1810	4.10	18.49	4043	715
2360	7940	1.92	21.20	2171	543	1.41	20.80	1564	391	1.80	20.18	1937	485
2480	8334	0.62	22.89	757	189	--	--	--	--	0.51	21.87	595	149
2600	8727	0.11	24.58	144	36	--	--	--	--	--	--	--	--
2720		338.71		232,942	16,779	925.29		580,460	34,656	188.73		131,966	9801

Total Area: 1452.73 square miles
Total Precipitation: 945,368 Acre-Feet/Year, Rounded to 945,000 AF/Yr in text
Total G.W. Recharge: 61,236 Acre-Feet/Year, Rounded to 61,000 AF/Yr in text

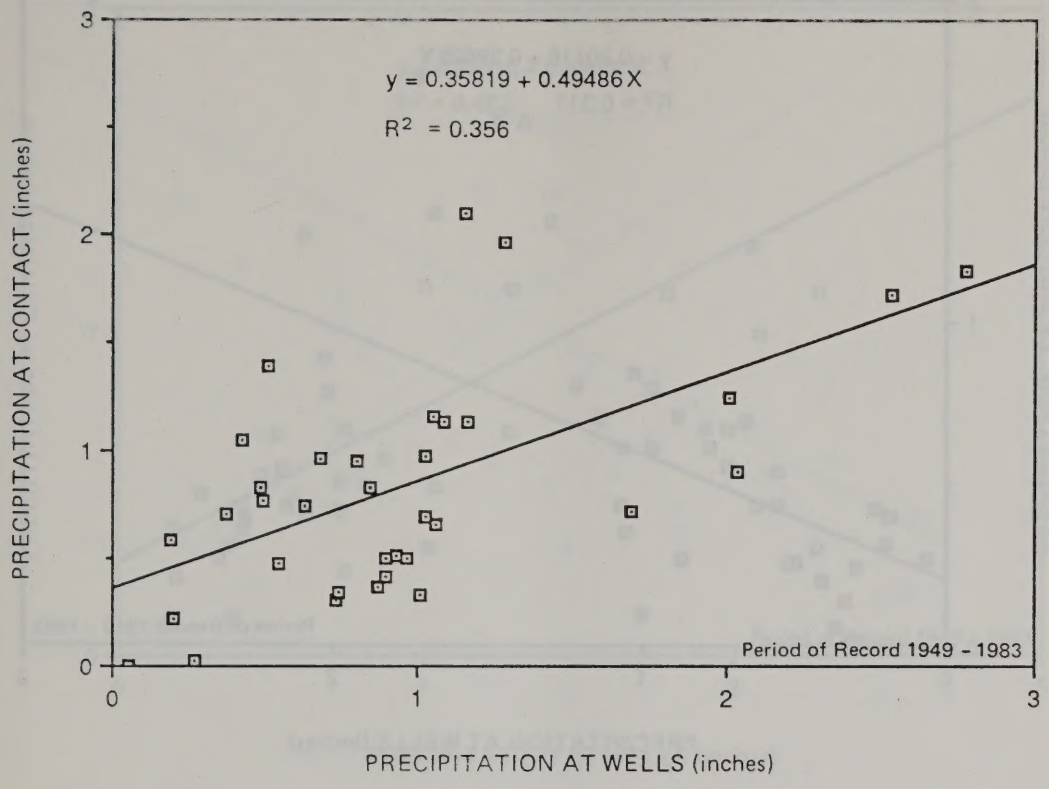
1 Mean precipitation within each elevation zone: $P = C + .004285 \times El$, feet, C calculated from average precipitation, 1949 through 1983, and station elevations at Contact, Montello, and Wells NOAA monitoring stations, respectively. $^{C}Contact = -12.82$, $^{C}Montello = -13.22$, $^{C}Wells = -13.84$.

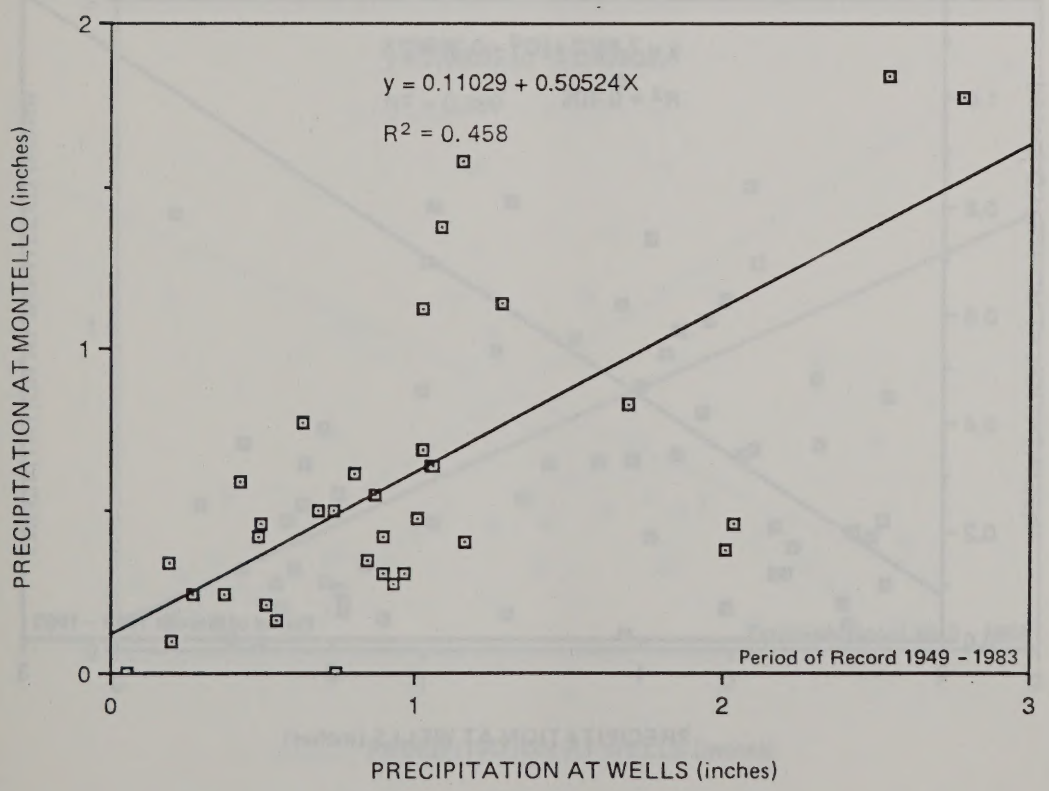
2 Groundwater recharge calculated as $R = 0.000028\ p^4$, where R is in in./yr over the area of the zone, and P is the estimated average annual precipitation in the zone for $P>8$ and ≤ 20 in./yr; for $P<8$, $R=0$ and for $P>20$ in./yr, $R = 0.25\ P$.

Table B-6. AVERAGE MONTHLY STREAMFLOWS MEASURED AT WILKINS, SHORES, AND MONTELLO USGS GAGING STATIONS - THOUSAND SPRINGS CREEK, 1985-88

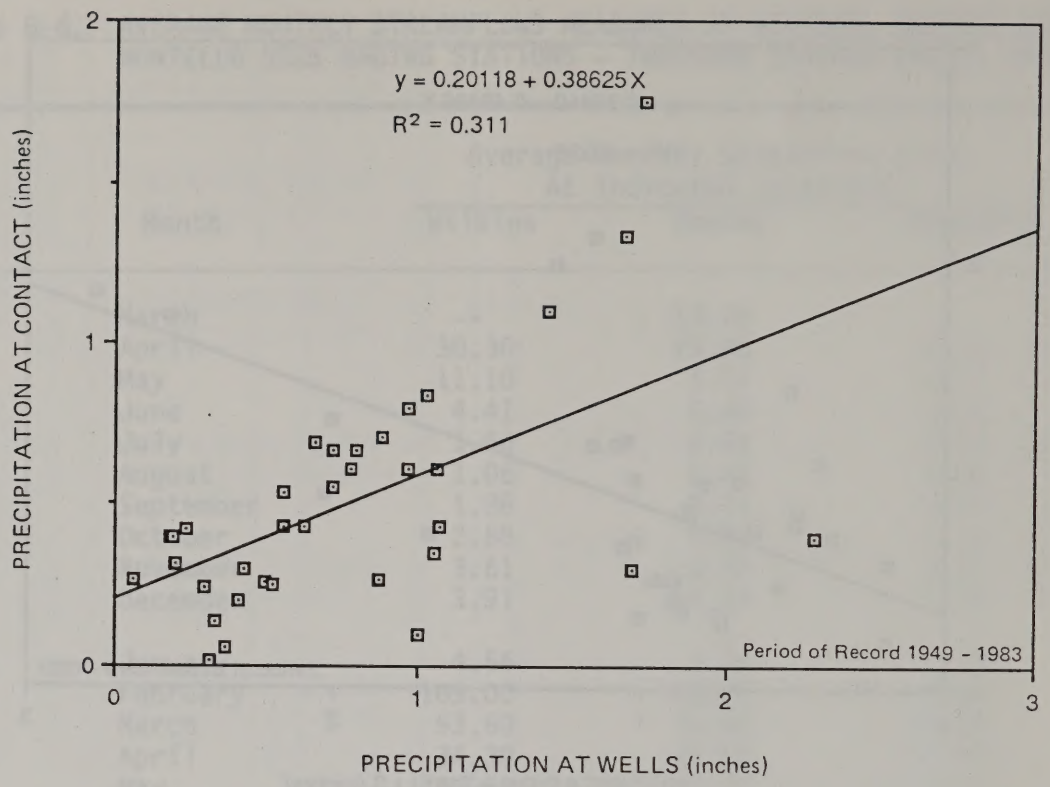
Year	Month	Average Monthly Streamflow (cfs) At Indicated Locations		
		Wilkins	Shores	Montello
1985	March	--	13.10	--
	April	30.30	29.80	4.65
	May	11.10	8.07	2.17
	June	4.41	0.46	1.03
	July	1.66	0.02	0.65
	August	1.06	0.02	0.34
	September	1.88	0.01	0.78
	October	2.58	0.03	1.12
	November	3.61	0.05	1.27
	December	3.91	0.09	1.18
1986	January	4.56	1.09	1.35
	February	109.00	93.50	4.66
	March	53.50	46.90	23.90
	April	34.30	30.60	27.40
	May	23.50	12.50	9.50
	June	8.67	0.70	1.10
	July	2.14	0.03	0.44
	August	1.49	0.03	0.39
	September	2.55	0.03	1.21
	October	3.54	0.03	1.15
	November	3.73	--	0.68
	December	3.13	--	0.58
1987	January	2.75	--	0.49
	February	3.23	--	0.68
	March	6.10	--	2.27
	April	5.91	--	0.84
	May	3.94	--	0.58
	June	1.45	--	0.28
	July	0.39	--	0.52
	August	0.01	--	0.20
	September	0.00	--	0.21
	October	0.65	--	0.36
	November	4.66	--	0.87
	December	4.50	--	1.52
1988	January	4.86	--	--
	February	5.11	--	--
	March	4.74	--	--
	April	5.28	--	1.50
	May	10.40	--	1.12

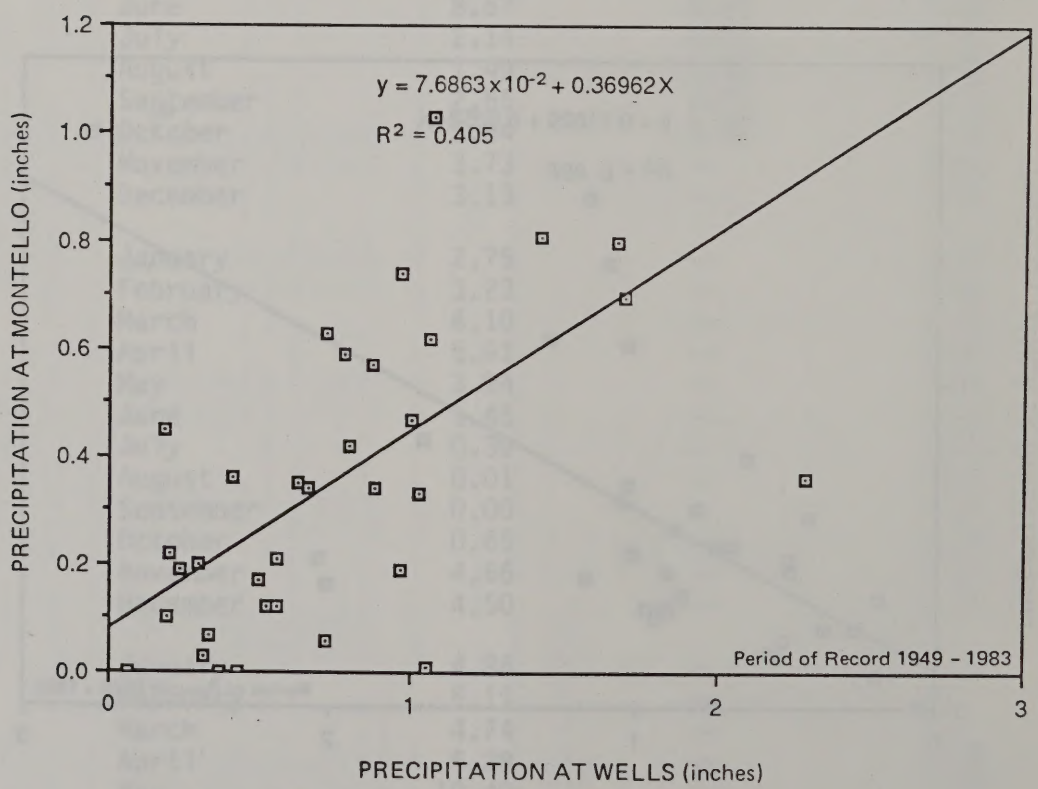
Data provided by United States Geological Survey. 1985-1988. Water Resources Data, Nevada, Water Year 1985, and Computer Generated Tables for Water Years 1986-1988.



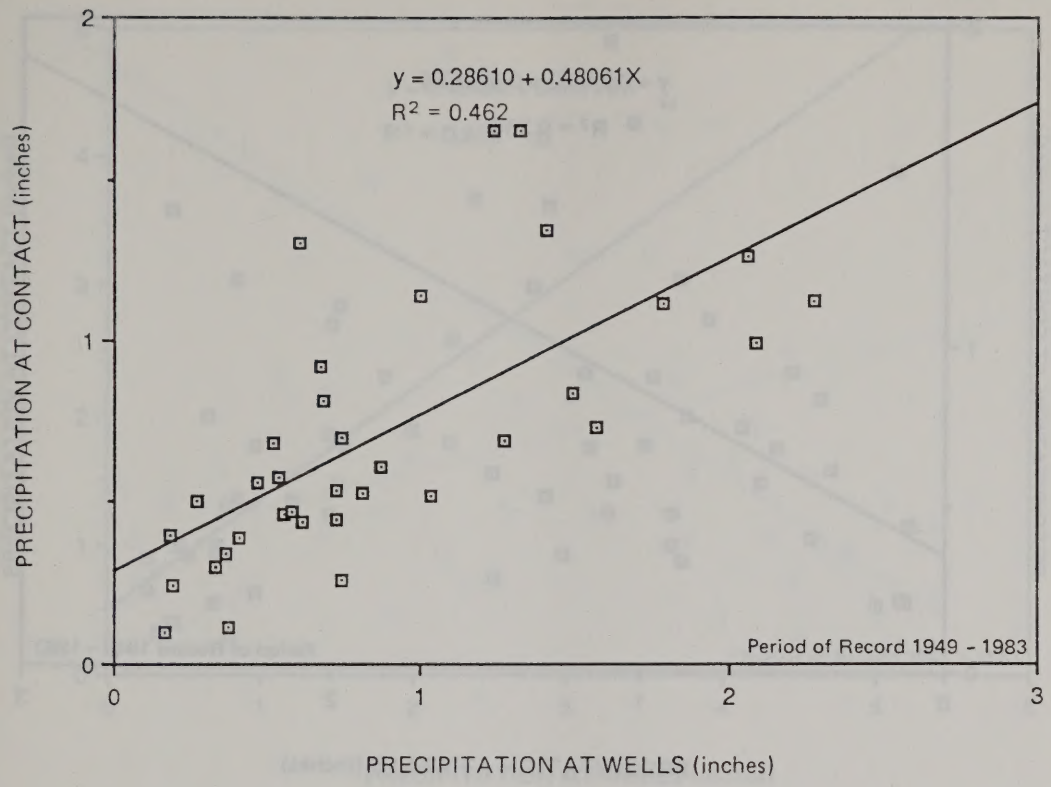


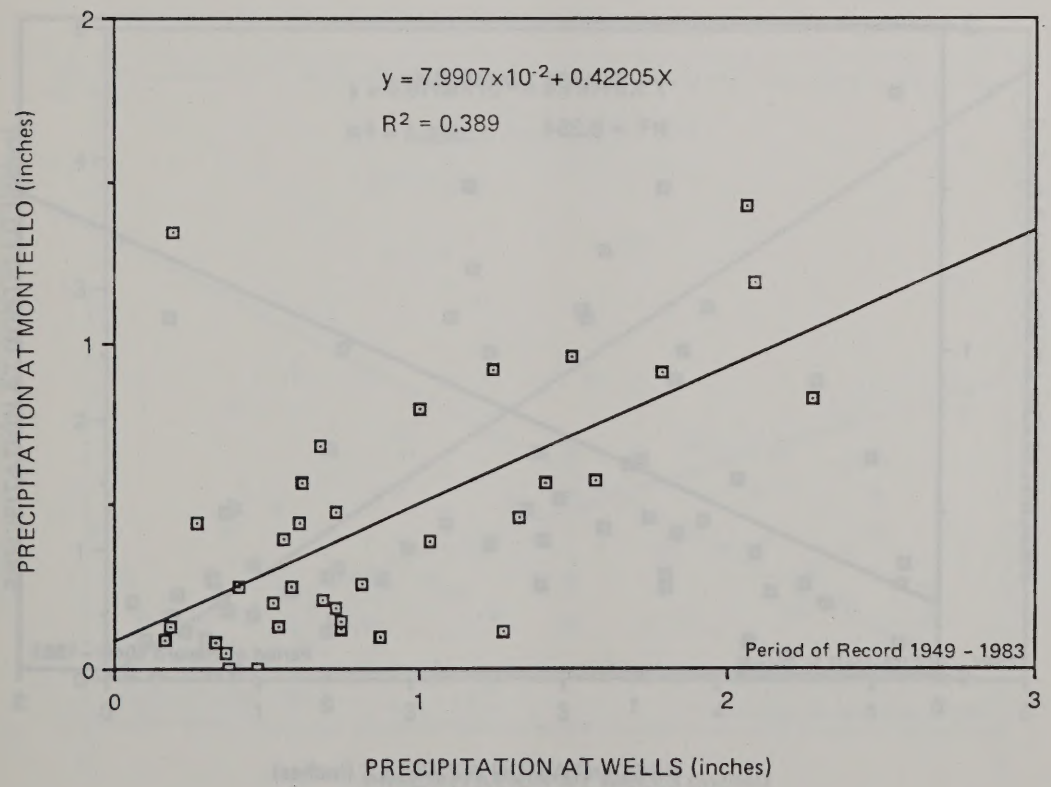
Project No. 90270B	Thousand Springs Power Plant	MONTHLY CORRELATION RELATIONSHIPS FOR PRECIPITATION , JANUARY	Figure B-1a
Woodward-Clyde Consultants			



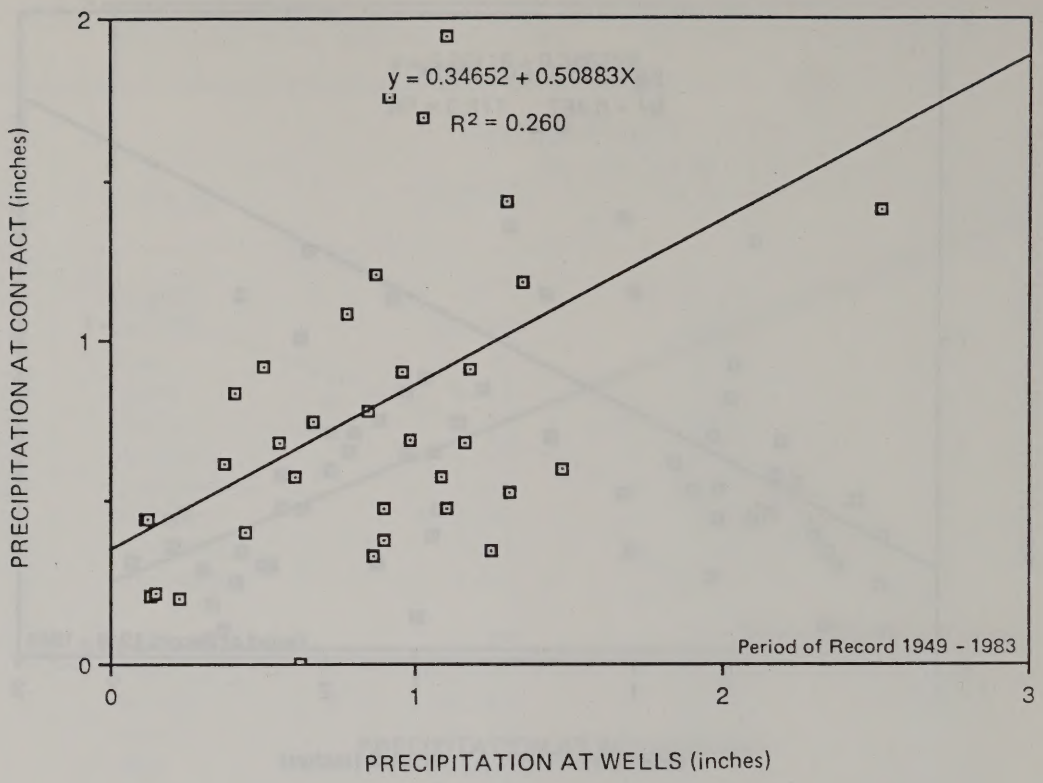


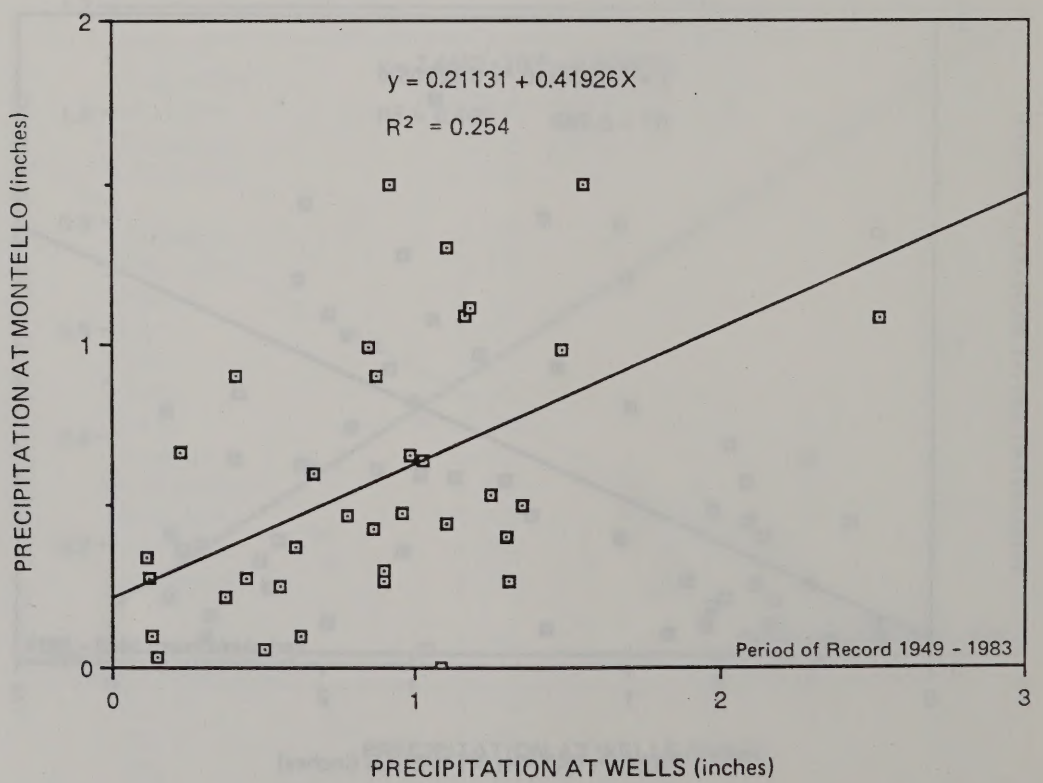
Project No. 90270B	Thousand Springs Power Plant	MONTHLY CORRELATION RELATIONSHIPS FOR PRECIPITATION, FEBRUARY	Figure B-1b
Woodward-Clyde Consultants			



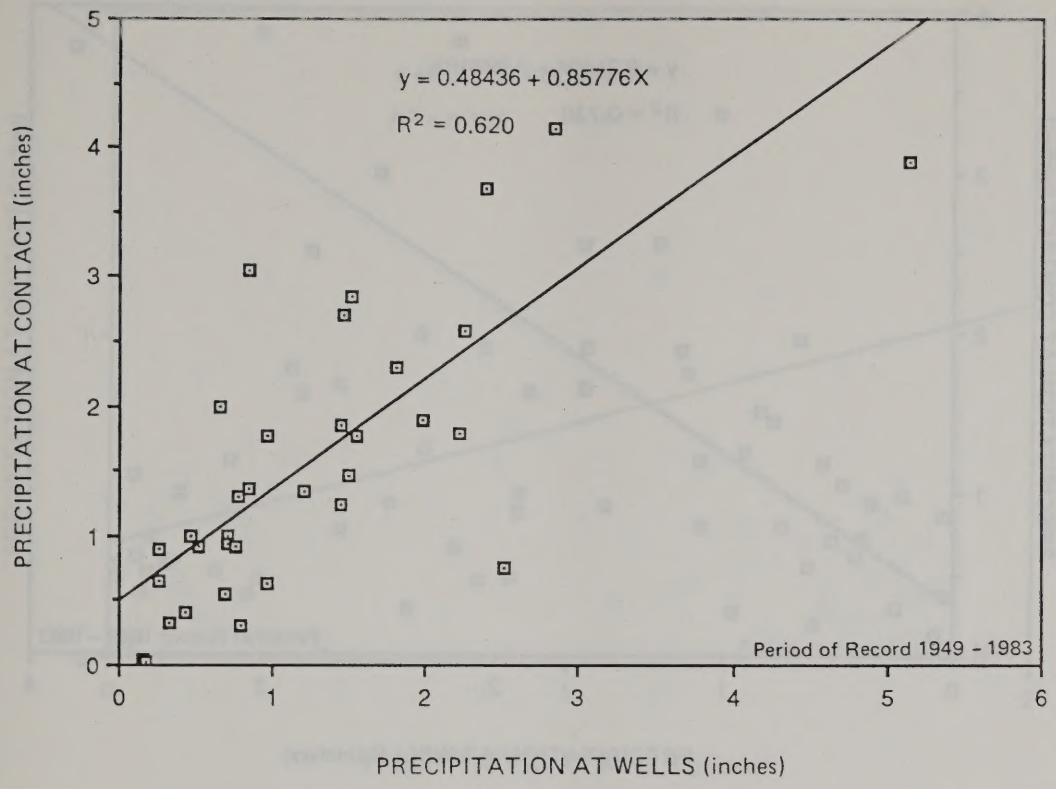


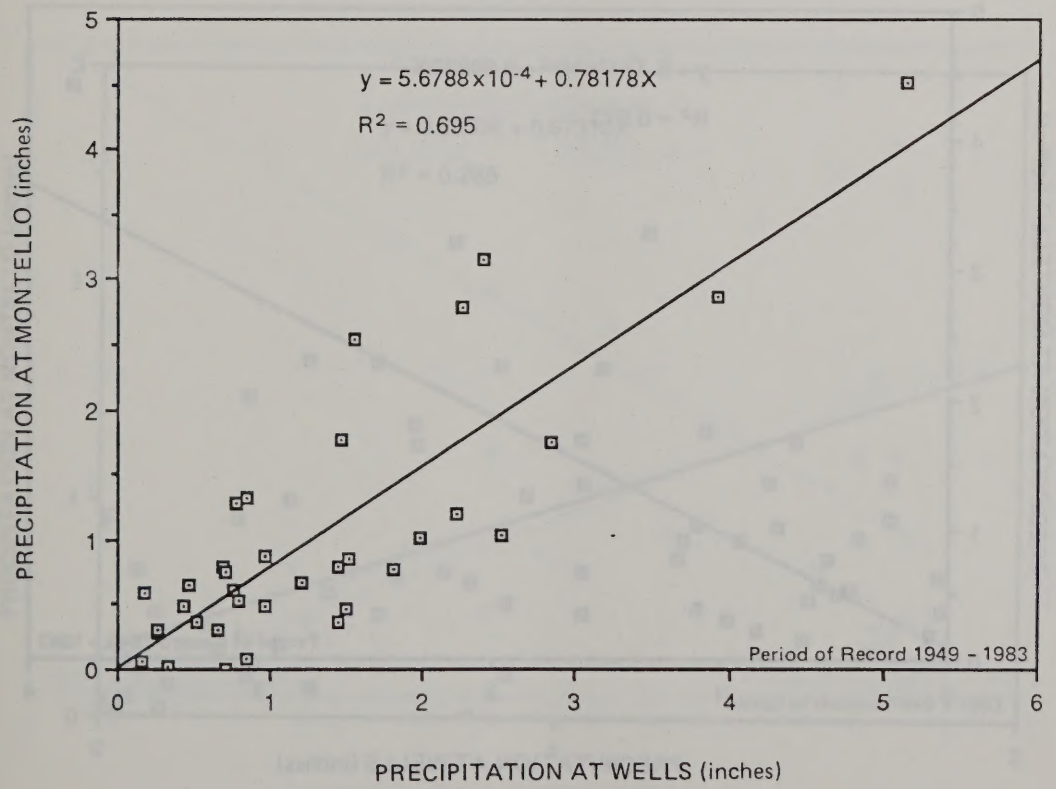
Project No. 90270B	Thousand Springs Power Plant	MONTHLY CORRELATION RELATIONSHIPS FOR PRECIPITATION, MARCH	Figure B-1c
Woodward-Clyde Consultants			



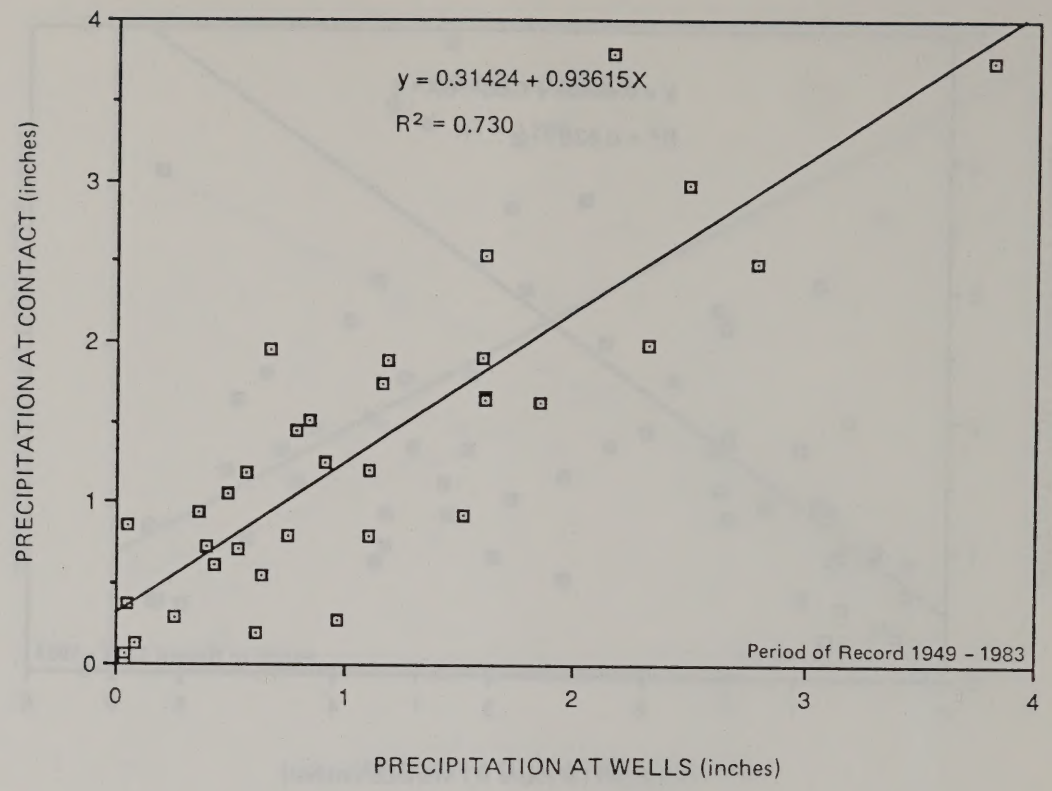


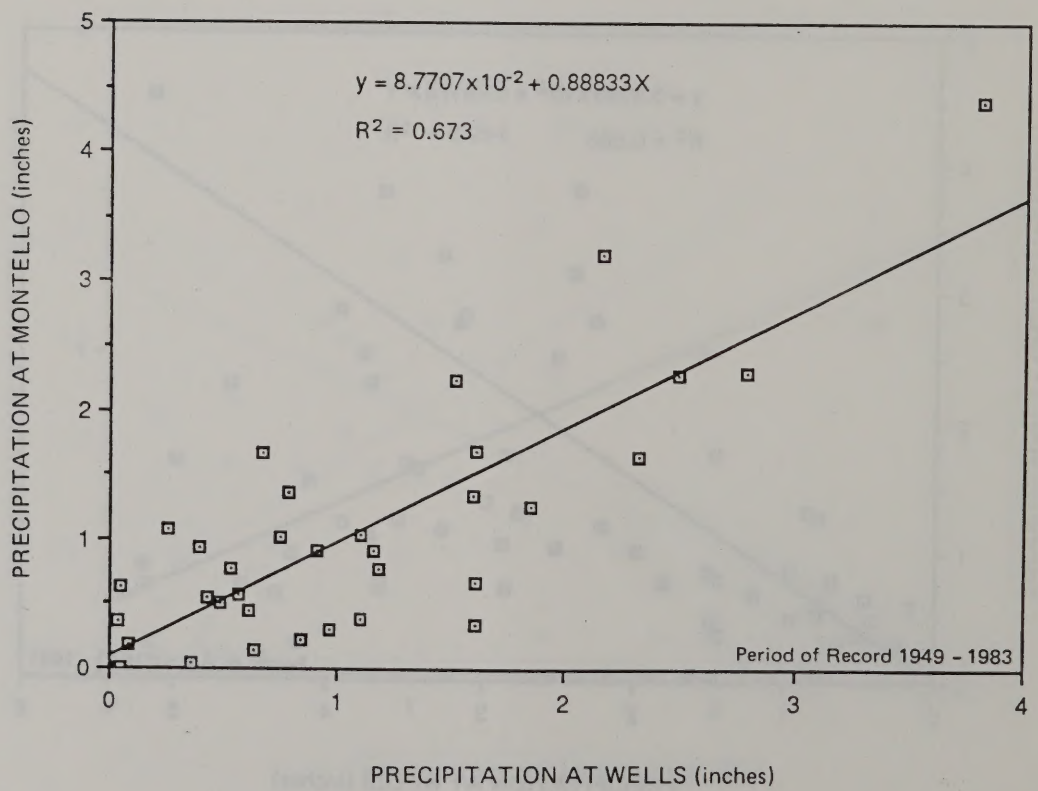
Project No. 90270B	Thousand Springs Power Plant	MONTHLY CORRELATION RELATIONSHIPS FOR PRECIPITATION, APRIL	Figure B-1d
Woodward-Clyde Consultants			



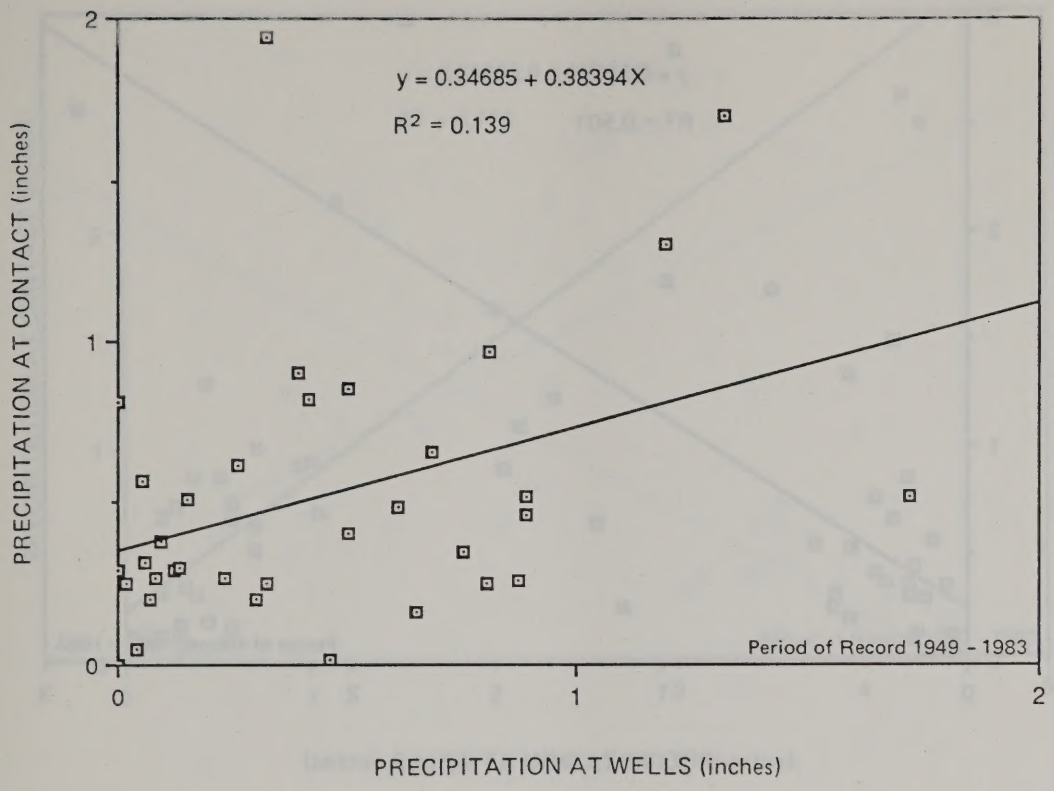


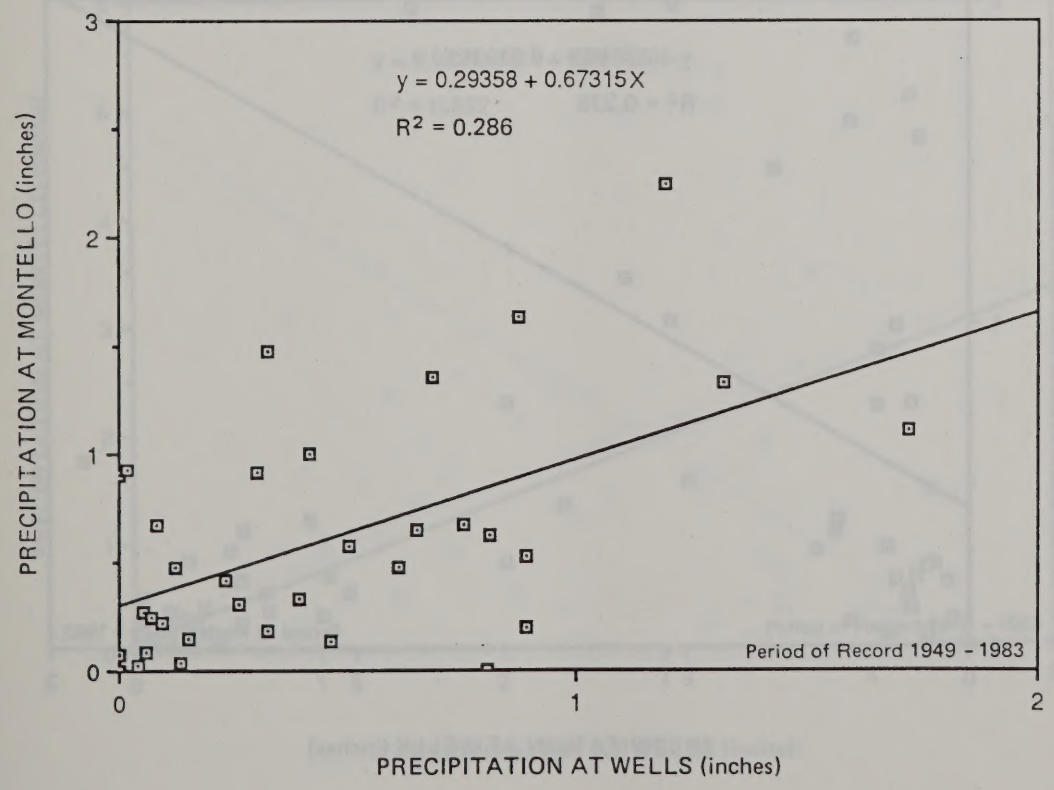
Project No. 90270B	Thousand Springs Power Plant	MONTHLY CORRELATION RELATIONSHIPS FOR PRECIPITATION, MAY	Figure B-1e
Woodward-Clyde Consultants			



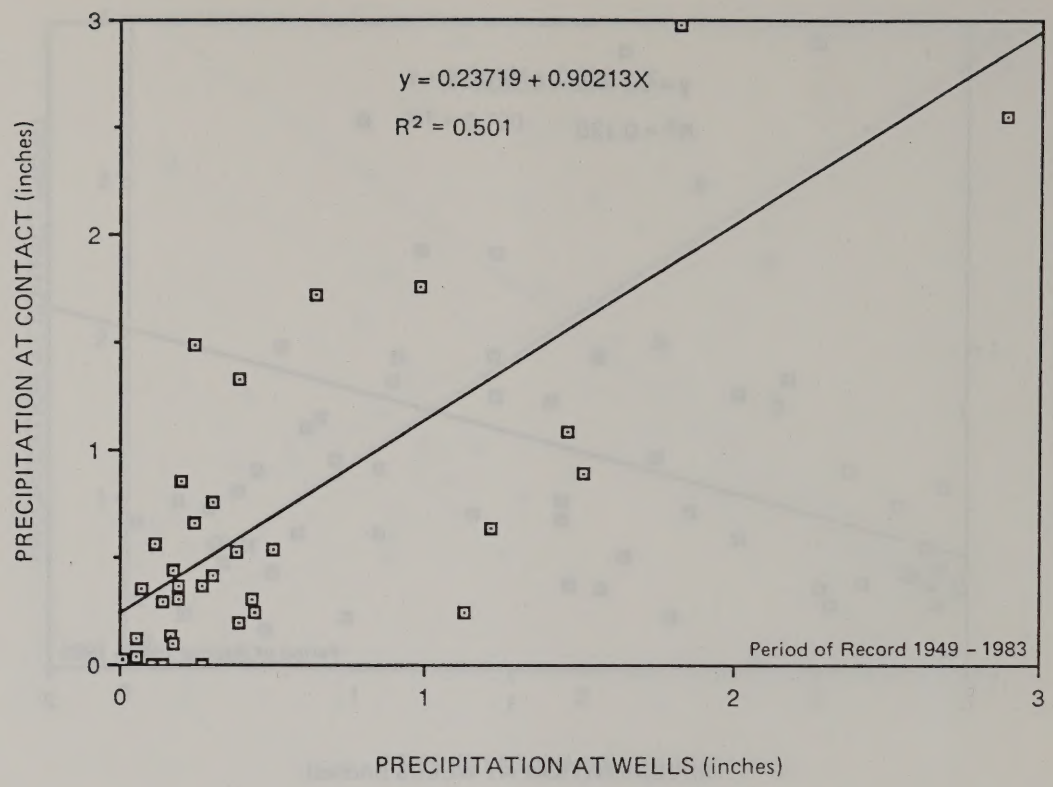


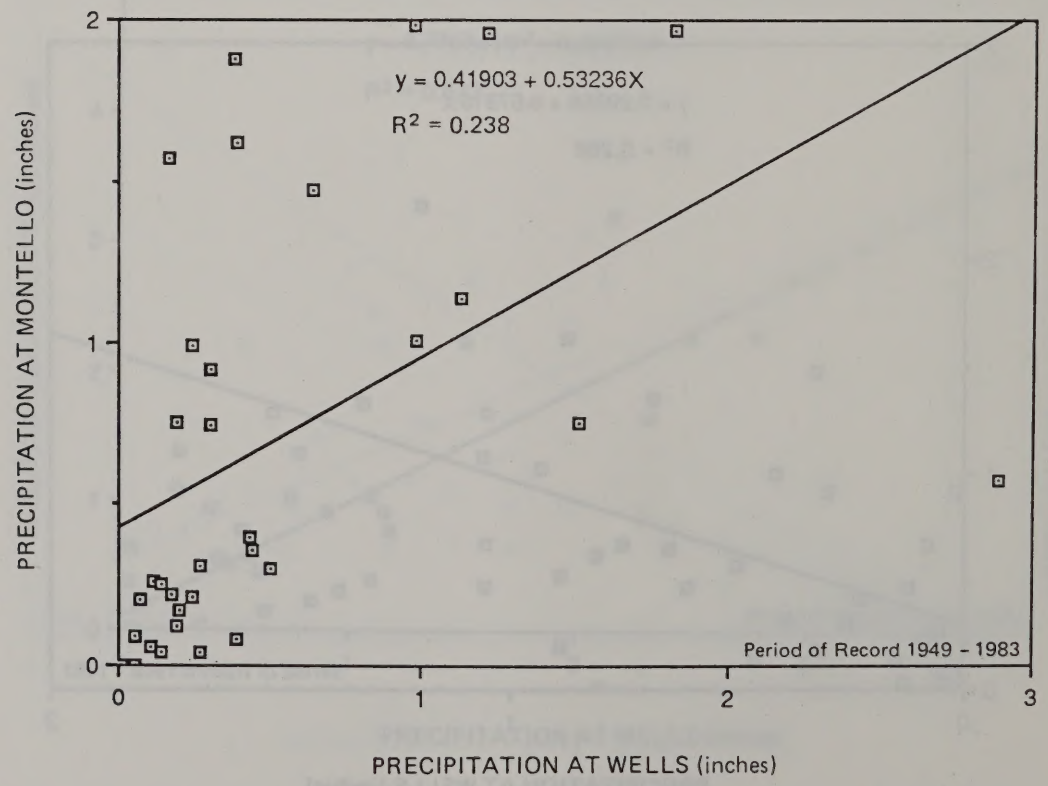
Project No. 90270B	Thousand Springs Power Plant	MONTHLY CORRELATION RELATIONSHIPS FOR PRECIPITATION, JUNE	Figure B-1f
Woodward-Clyde Consultants			



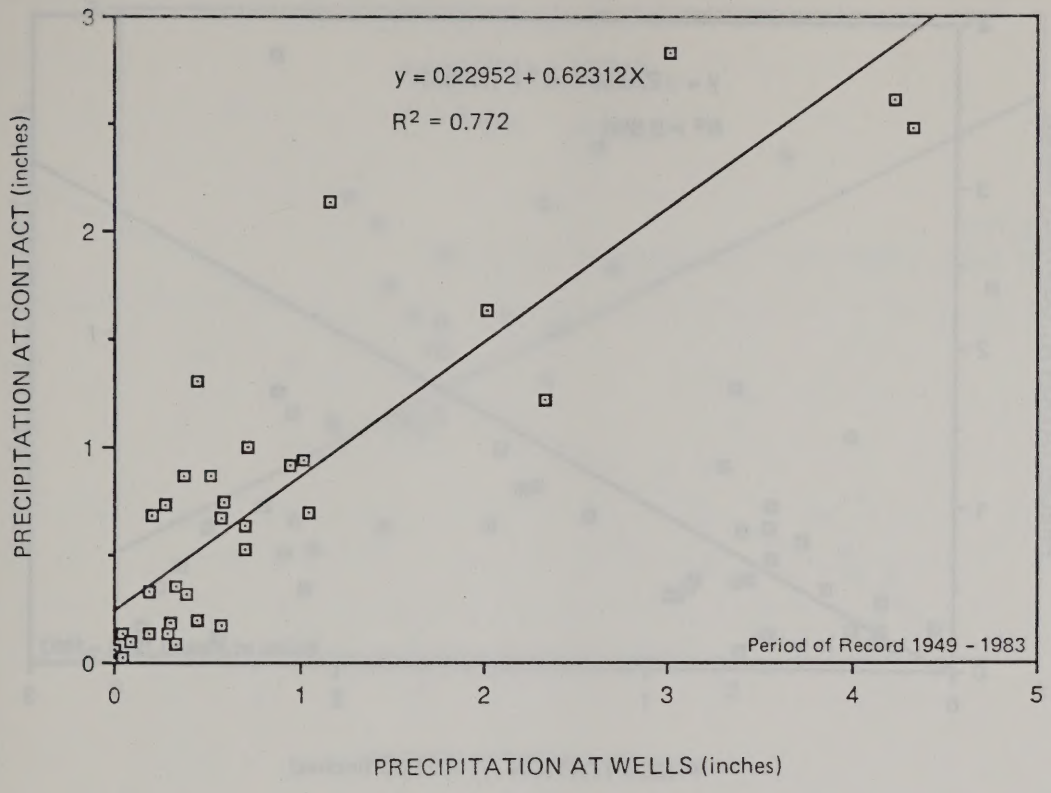


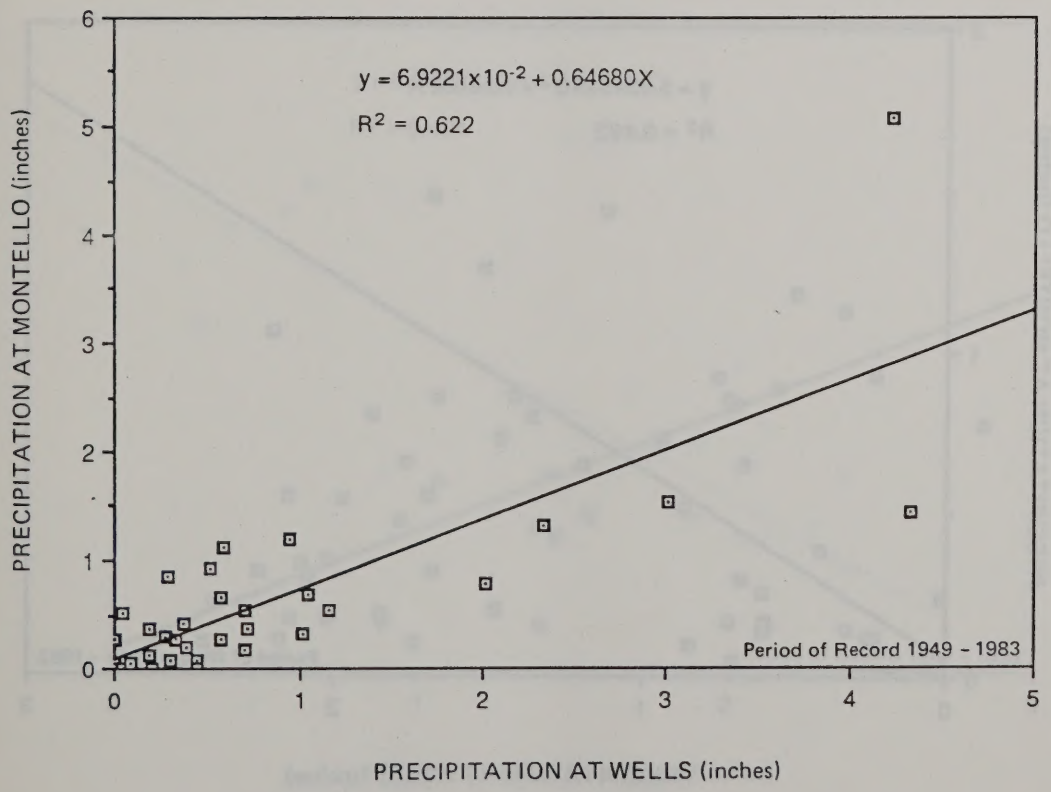
Project No. 90270B	Thousand Springs Power Plant	MONTHLY CORRELATION RELATIONSHIPS FOR PRECIPITATION, JULY	Figure B-1g
Woodward-Clyde Consultants			



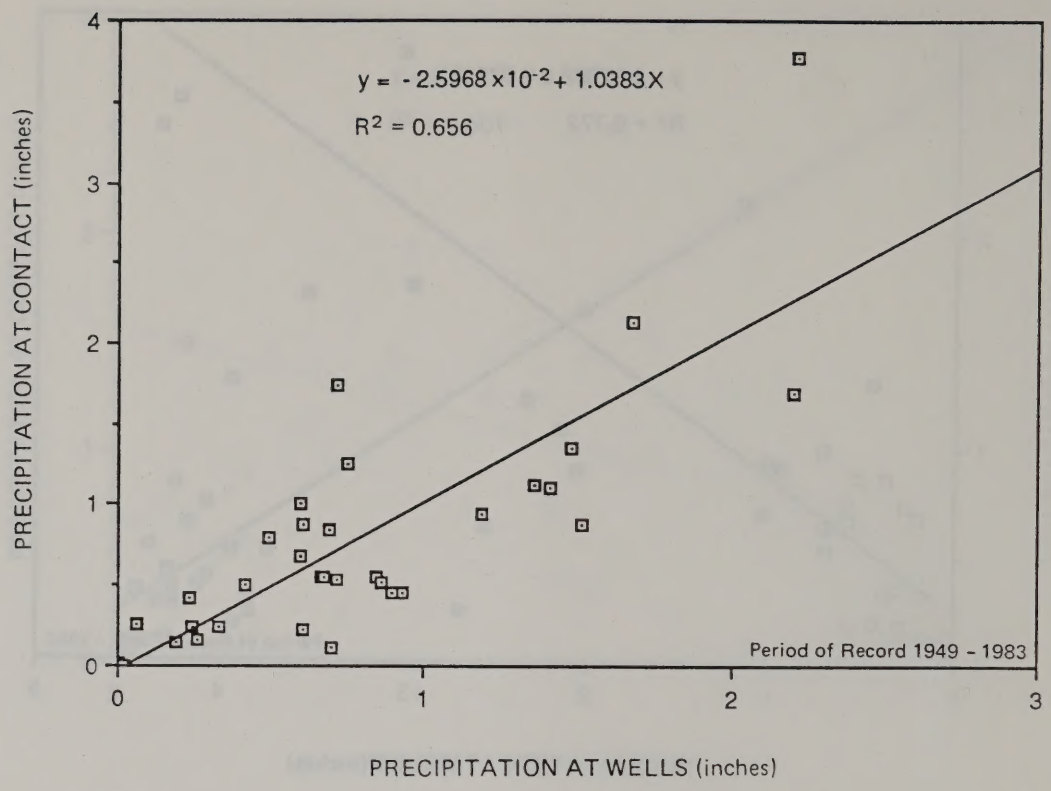


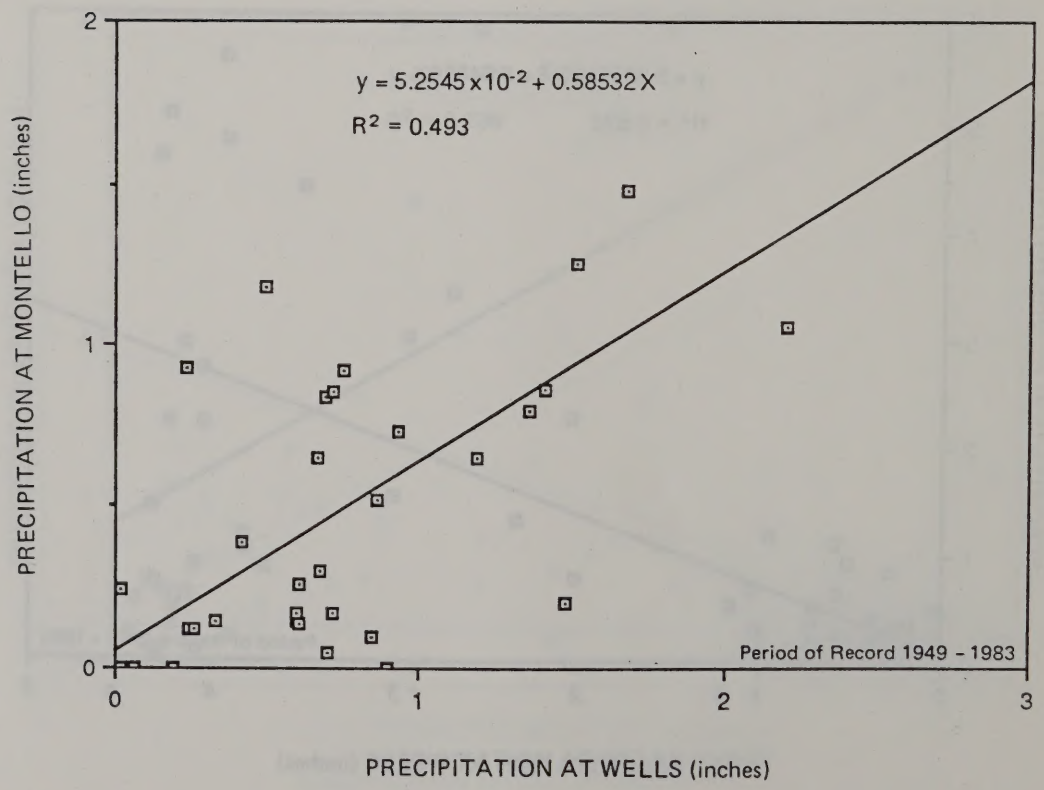
Project No. 90270B	Thousand Springs Power Plant	MONTHLY CORRELATION RELATIONSHIPS FOR PRECIPITATION, AUGUST	Figure B-1h
Woodward-Clyde Consultants			



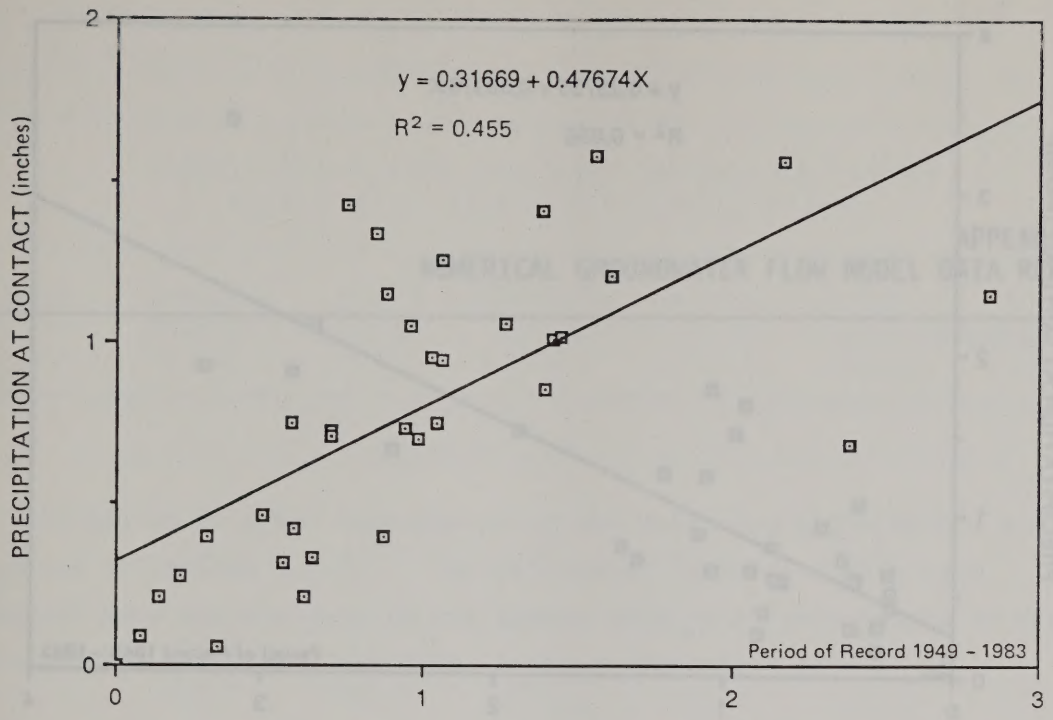


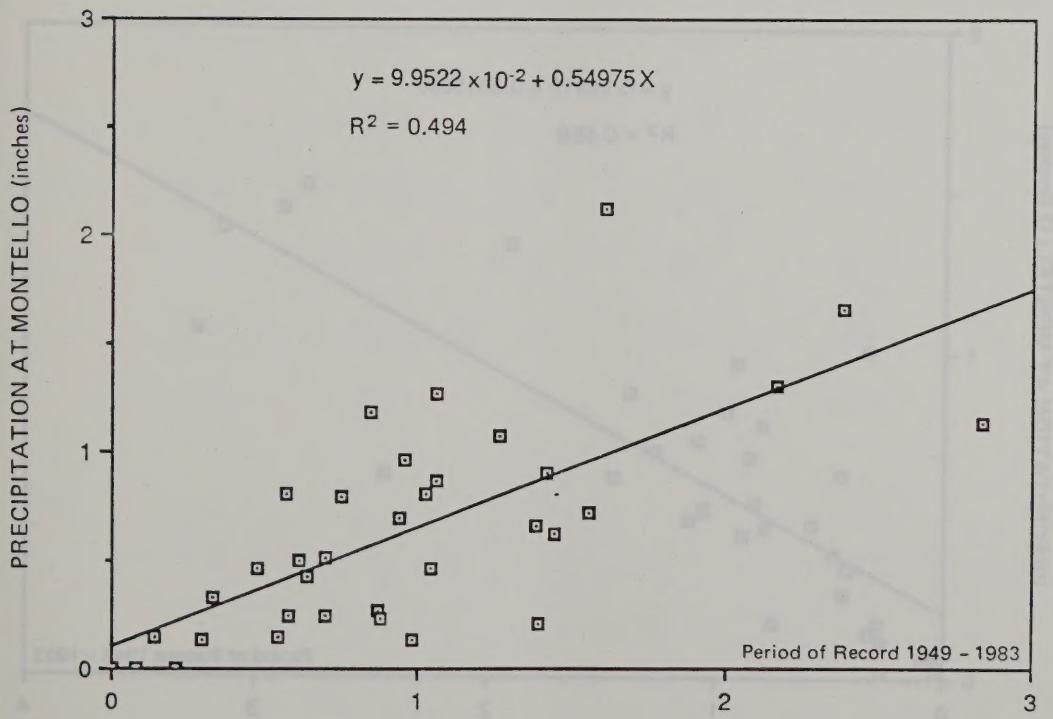
Project No. 90270B	Thousand Springs Power Plant	MONTHLY CORRELATION RELATIONSHIPS FOR PRECIPITATION, SEPTEMBER	Figure B-1i
Woodward-Clyde Consultants			



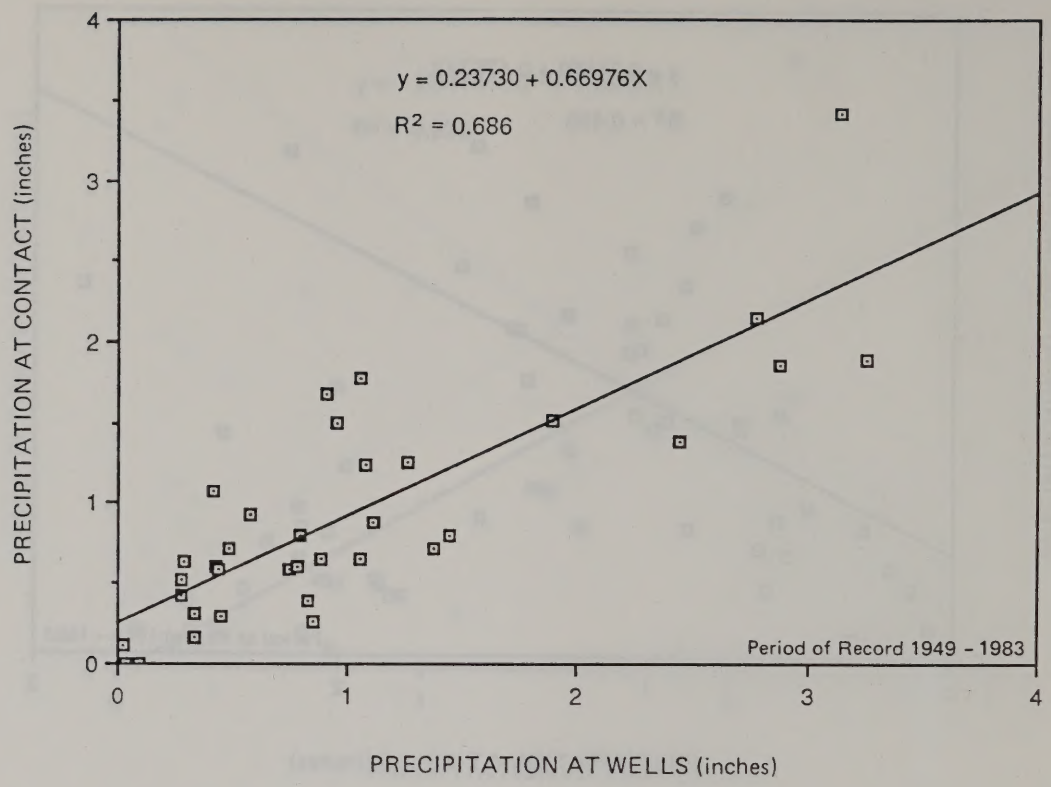


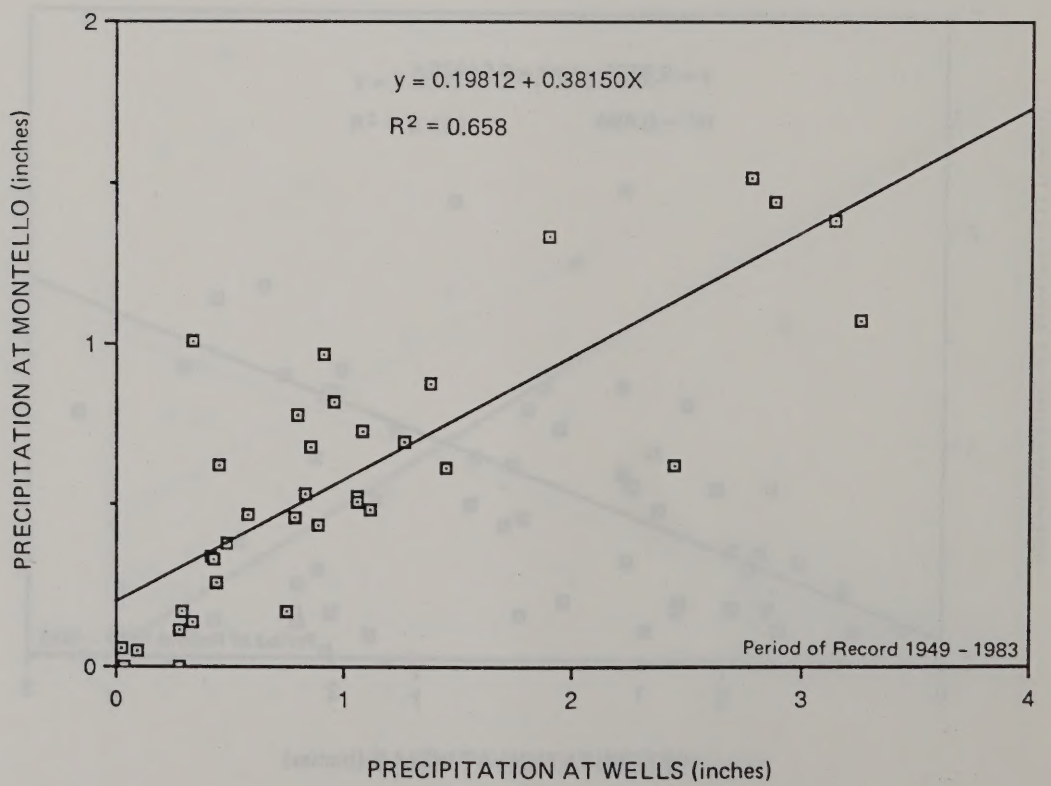
Project No. 90270B	Thousand Springs Power Plant	MONTHLY CORRELATION RELATIONSHIPS FOR PRECIPITATION, OCTOBER	Figure B-1j
Woodward-Clyde Consultants			





Project No. 90270B	Thousand Springs Power Plant	MONTHLY CORRELATION RELATIONSHIPS FOR PRECIPITATION, NOVEMBER	Figure B-1k
Woodward-Clyde Consultants			





Project No. 90270B	Thousand Springs Power Plant	MONTHLY CORRELATION RELATIONSHIPS FOR PRECIPITATION, DECEMBER	Figure B-11
Woodward-Clyde Consultants			

APPENDIX C
NUMERICAL GROUNDWATER FLOW MODEL DATA REPORT

APPENDIX C-1

Estimation of areal recharge using the Maxey and Eakin Method as discussed in Section 8.1.3.1. The calculated recharge within each elevation zone was assigned to the appropriate model grid points in the groundwater model as the estimated initial recharge.

Table C-1. TOANO DRAW AND ROCKY BUTTE WATERSHEDS

Period of Analysis = Long Term Average (1949-1987)
Total Drainage Area = 450.60 square miles

Elevation (m, msl)	Mean Elevation (m, msl)	Mean Elevation (ft, msl)	Drainage Area (mi^2)	Precip. Depth (in.)	Equivalent Recharge (in.)	Recharge Volume (ac-ft)
Portion of Toano Draw and Rocky Butte Within Wells Subarea						
1400						
	1460	4790	0	0	0	0
1520						
	1580	5184	0	0	0	0
1640						
	1700	5578	0.10	10.06	0.29	1.55
1760						
	1820	5971	25.74	11.75	0.53	727.58
1880						
	1940	6365	21.14	13.43	0.91	1025.99
2000						
	2060	6759	8.38	15.12	1.46	652.52
2120						
	2180	7153	4.59	16.81	2.24	548.35
2240						
	2300	7546	2.22	18.49	3.27	387.17
2360						
	2420	7940	0.53	20.18	5.05	142.75
2480						
	2540	8334	0	0	0	0
2600						
	2660	8727	0	0	0	0
2720						
	Total		62.70			3485.91

Table C-2. TOANO DRAW WATERSHED AND ROCKY BUTTE

Period of Analysis = Long Term Average (1949-1987)
Total Drainage Area = 450.60 square miles

Elevation (m, msl)	Mean Elevation (m, msl)	Mean Elevation (ft, msl)	Drainage Area (mi^2)	Precip. Depth (in.)	Equivalent Recharge (in.)	Recharge Volume (ac-ft)
Portion of Toano Draw and Rocky Butte Within Contact Subarea						
1400						
	1460	4790	0	0	0	0
1520						
	1580	5184	5.23	9.39	0.22	61.37
1640						
	1700	5578	8.98	11.08	0.42	201.15
1760						
	1820	5971	0.30	12.77	0.74	11.84
1880						
	1940	6365	0	0	0	0
2000						
	2060	6759	0	0	0	0
2120						
	2180	7153	0	0	0	0
2240						
	2300	7546	0	0	0	0
2360						
	2420	7940	0	0	0	0
2480						
	2540	8334	0	0	0	0
2600						
	2660	8727	0	0	0	0
2720						
	Total		14.51			274.36

Table C-3. TOANO DRAW WATERSHED AND ROCKY BUTTE

Period of Analysis = Long Term Average (1949-1987)
Total Drainage Area = 450.60 square miles

Elevation (m, msl)	Mean Elevation (m, msl)	Mean Elevation (ft, msl)	Drainage Area (mi^2)	Precip. Depth (in.)	Equivalent Recharge (in.)	Recharge Volume (ac-ft)
Portion of Toano Draw and Rocky Butte Within Montello Subarea						
1400						
	1460	4790	0.18	7.31	0	0
1520						
	1580	5184	19.41	8.99	0.18	189.33
1640						
	1700	5578	133.09	10.68	0.36	2585.75
1760						
	1820	5971	134.51	12.37	0.66	4703.16
1880						
	1940	6365	53.68	14.05	1.09	3123.74
2000						
	2060	6759	21.63	15.74	1.72	1982.59
2120						
	2180	7153	8.08	17.43	2.58	1113.67
2240						
	2300	7546	2.30	19.11	3.73	458.07
2360						
	2420	7940	0.51	20.80	5.20	141.44
2480						
	2540	8334	0	0	0	0
2600						
	2660	8727	0	0	0	0
2720						
	Total		373.39			14,297.75

Total recharge to Toano Draw and Rocky Butte = 18,000 ac-ft
or = 0.75 in./yr

APPENDIX C-2

Available cross-sectional data on Thousand Springs Creek are presented below. The data were used to estimate the cross section of the Creek at nodal grid points in the groundwater model (see Section 8.1.3.3).

CHILTON Engineering and Surveying Ltd.

19 December 1988

Woodward Clyde Consultants
500 12th Street, Suite 100
Oakland, CA 94607-4014

Attention: Mr. Al Hasson

Subject: Thousand Spring Creek
Hydrologic Monitoring
CE&S Job No. 5000.001

Dear Mr. Hasson:

Per your phone request 12 December 1988 for cross-section data on the Thousand Spring Creek flow measuring sites.

I have prepared cross-sections on seven (7) flow measuring sites using current meter notes of high flows. Bank heights shown above water level are only estimates.

Also included is a brief description of measuring sites where velocity measurements were made at the entrance or outflow of culverts.

Sincerely,

CHILTON ENGINEERING and SURVEYING, LTD.

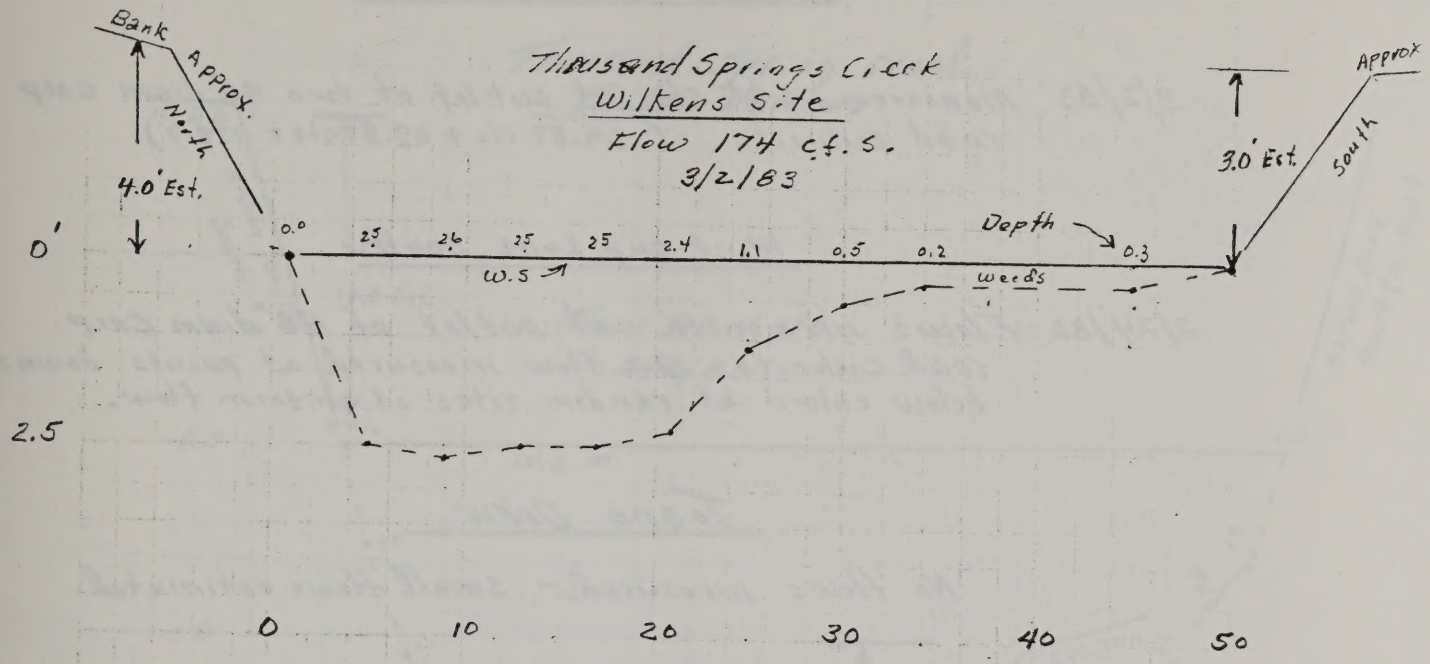
J. W. Griswold

JWG/emw

Enclosures

cc: Mr. M.B. Bennedsen

421 COURT ELKO, NEVADA 89801 (702) 738-2121
FAX (702) 738-7955



Wilkens Canal.

2/24/83 - Measured 20.5 cfs at 24" diam CM.P highway culvert.

Wine Cup Lane North

2/24/83 - Measured 78.4 cfs at outlet of three 36" diam C.M.P. road culverts (32.67 cfs + 28.89 cfs. + 16.87 cfs = 78.4)

Beaver Culvert

2/24/86 - Measured 9.2 cfs at outlet of 36" diam. CM P road culvert.

Wine cup Lane Center

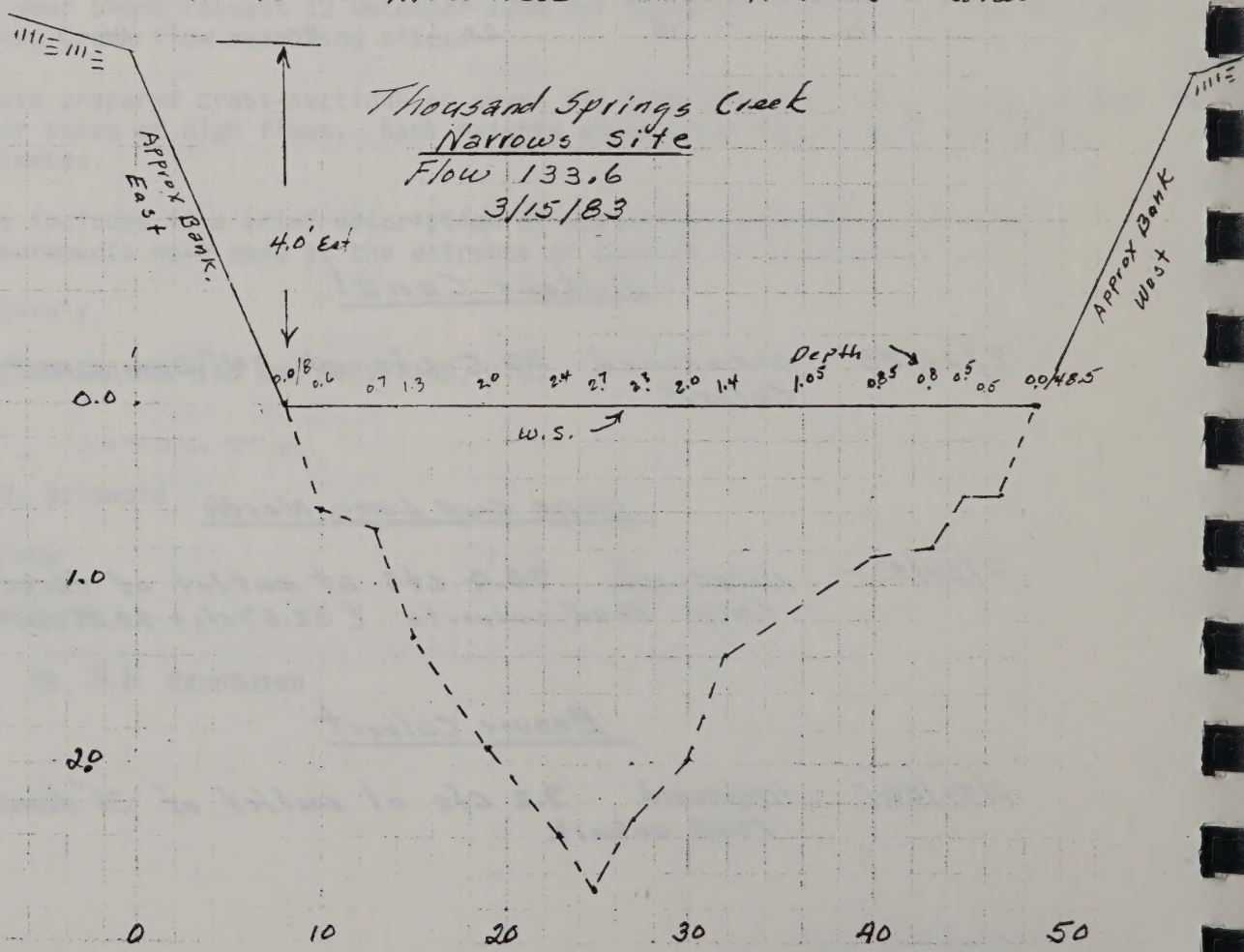
3/2/83 Measured 134.7 cfs at outlet of two 48" diam CMP road culverts. (64.89 cfs + 69.82 cfs = 134.7)

Wine cup Lane South

2/24/83 Flows measured at outlet of 48" diam CMP road culvert. Low flow measured at points downstream below culvert at random sites of uniform flow.

Toano Draw

No flows measured - small flows estimated.



PROJECT ..... PROJECT NO. .....

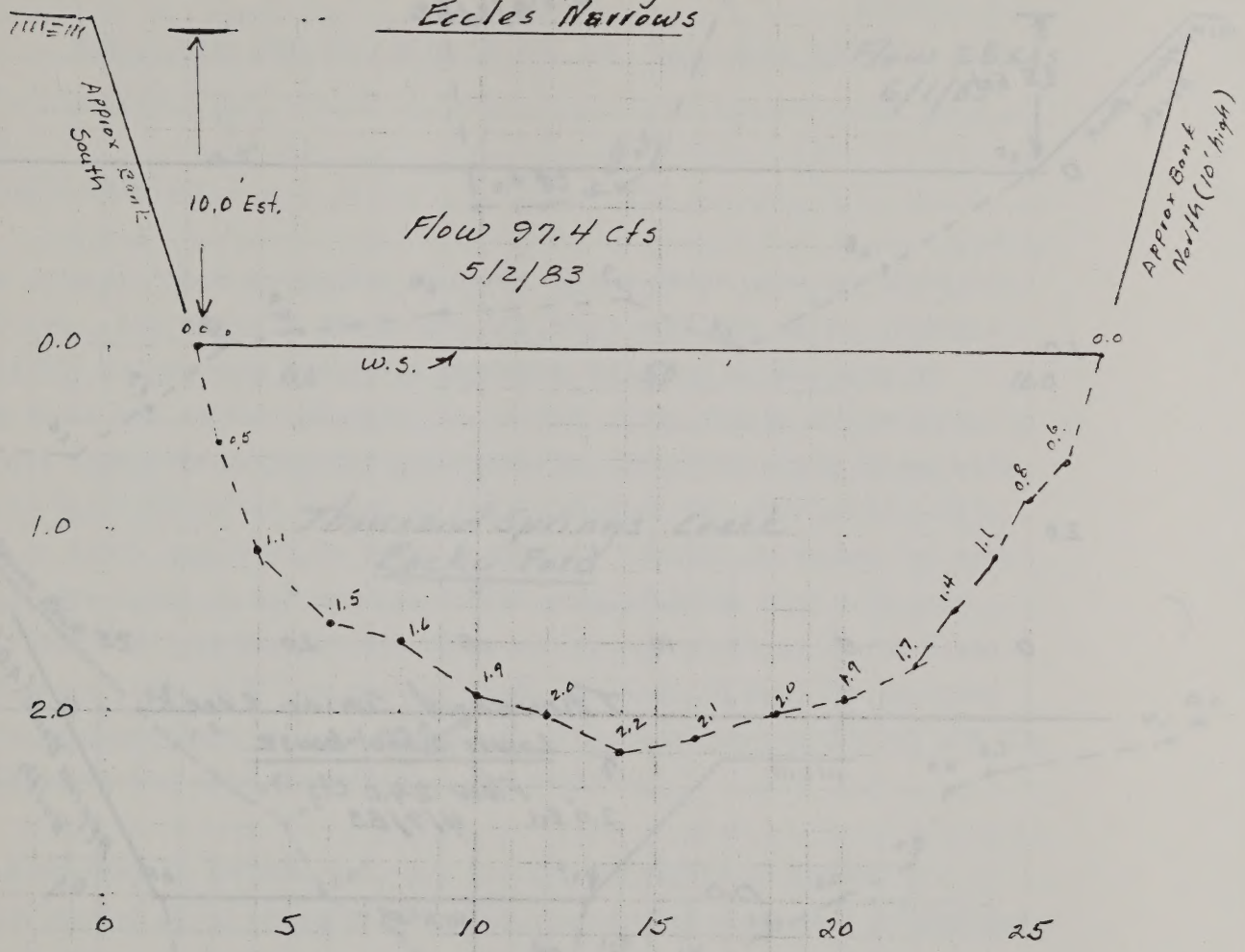
..... BY ..... DATE .....

..... SHEET NO. 2 OF 5 .....

Rock Springs Creek

Flows Measured at 8.0ft diam culvert

Thousand Spring Creek
Eccles Narrows



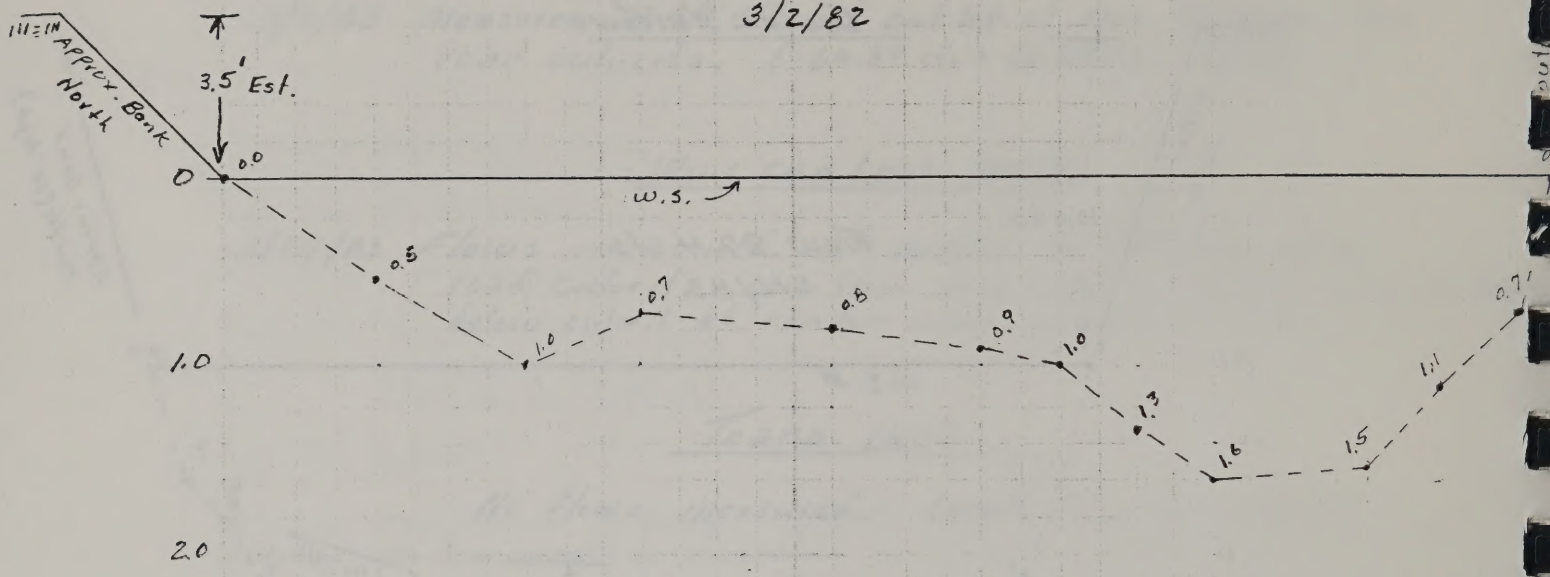
PROJECT ..... PROJECT NO. .....

..... BY ..... DATE .....

..... SHEET NO. 3 ..... OF 5 .....

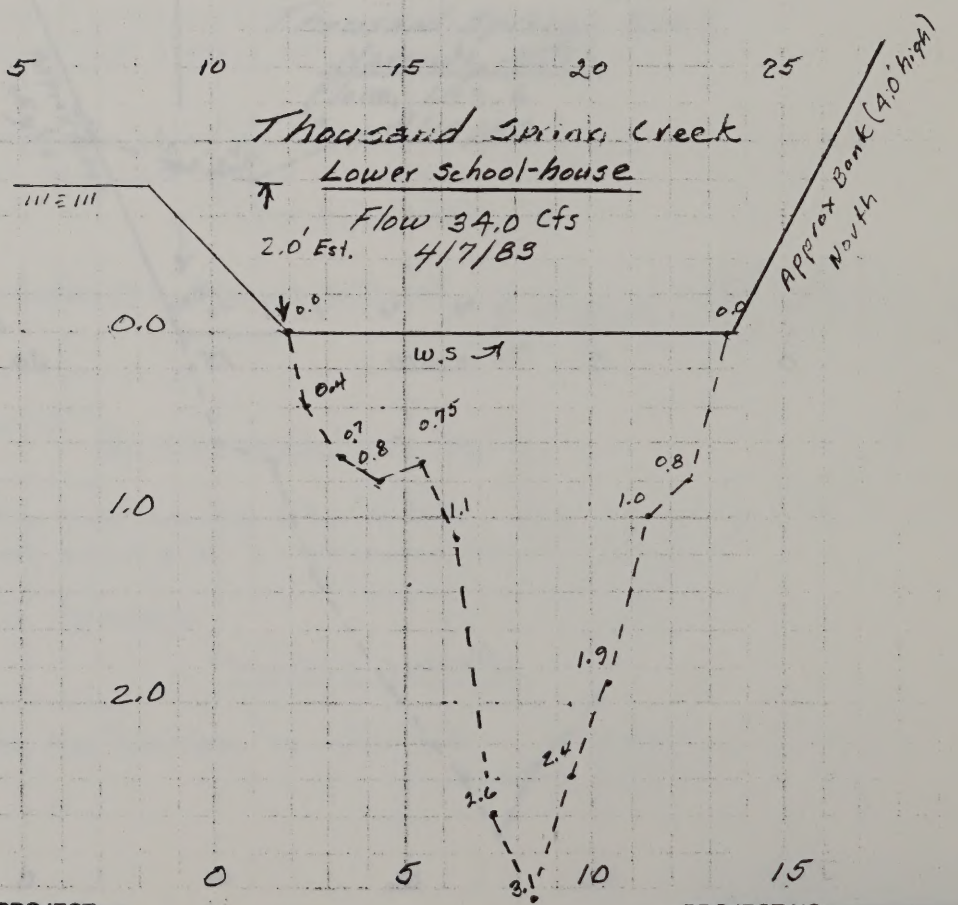
Thousand Spring Creek
Twenty-One mile Set.

Flow 94.1 c.f.s.
3/2/82



Thousand Spring Creek
Lower School-house

Flow 34.0 Cfs
4/7/83

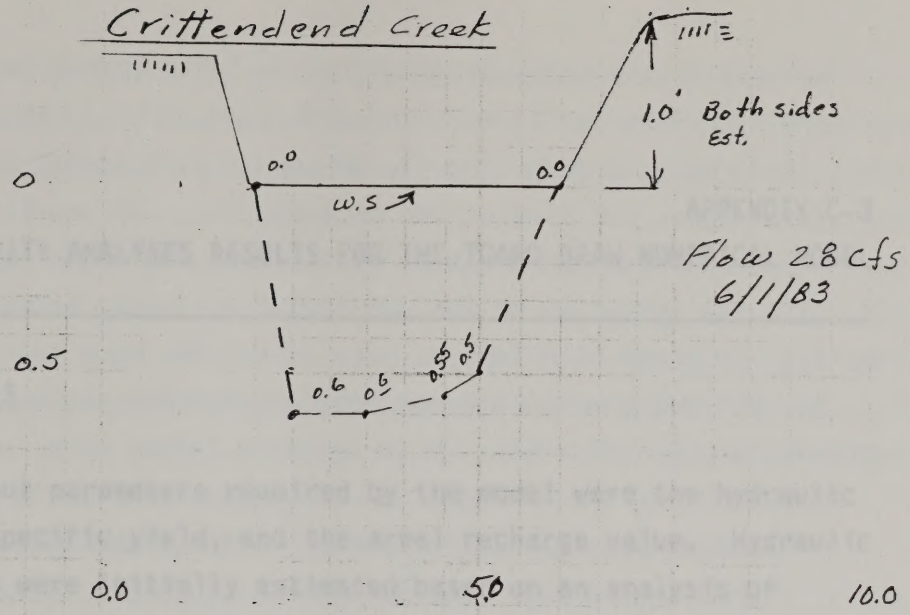


PROJECT ..... PROJECT NO. .....

..... BY ..... DATE .....

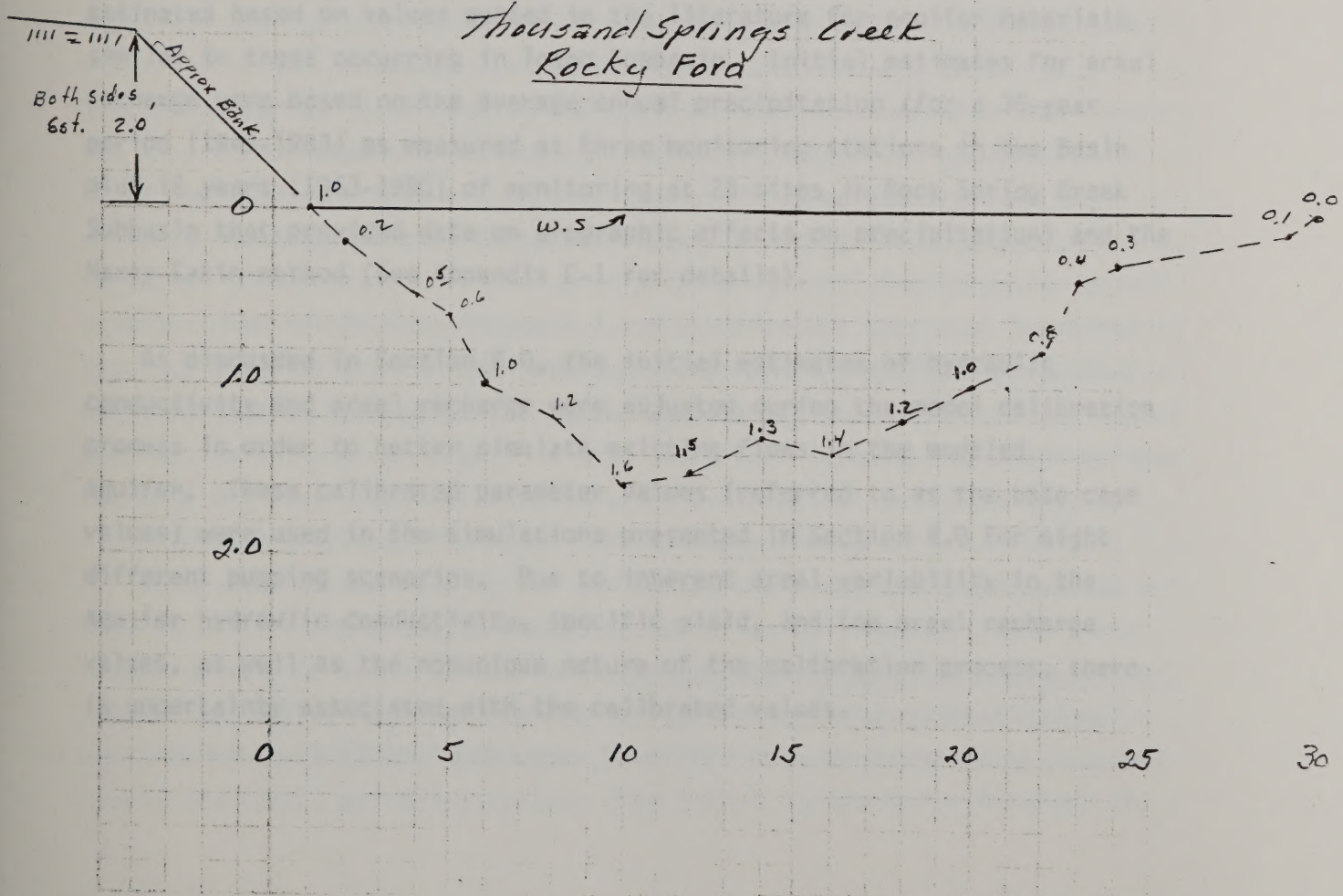
..... SHEET NO. 4 ..... OF 5 .....

Crittendend Creek



Flow 2.8 cfs
6/1/83

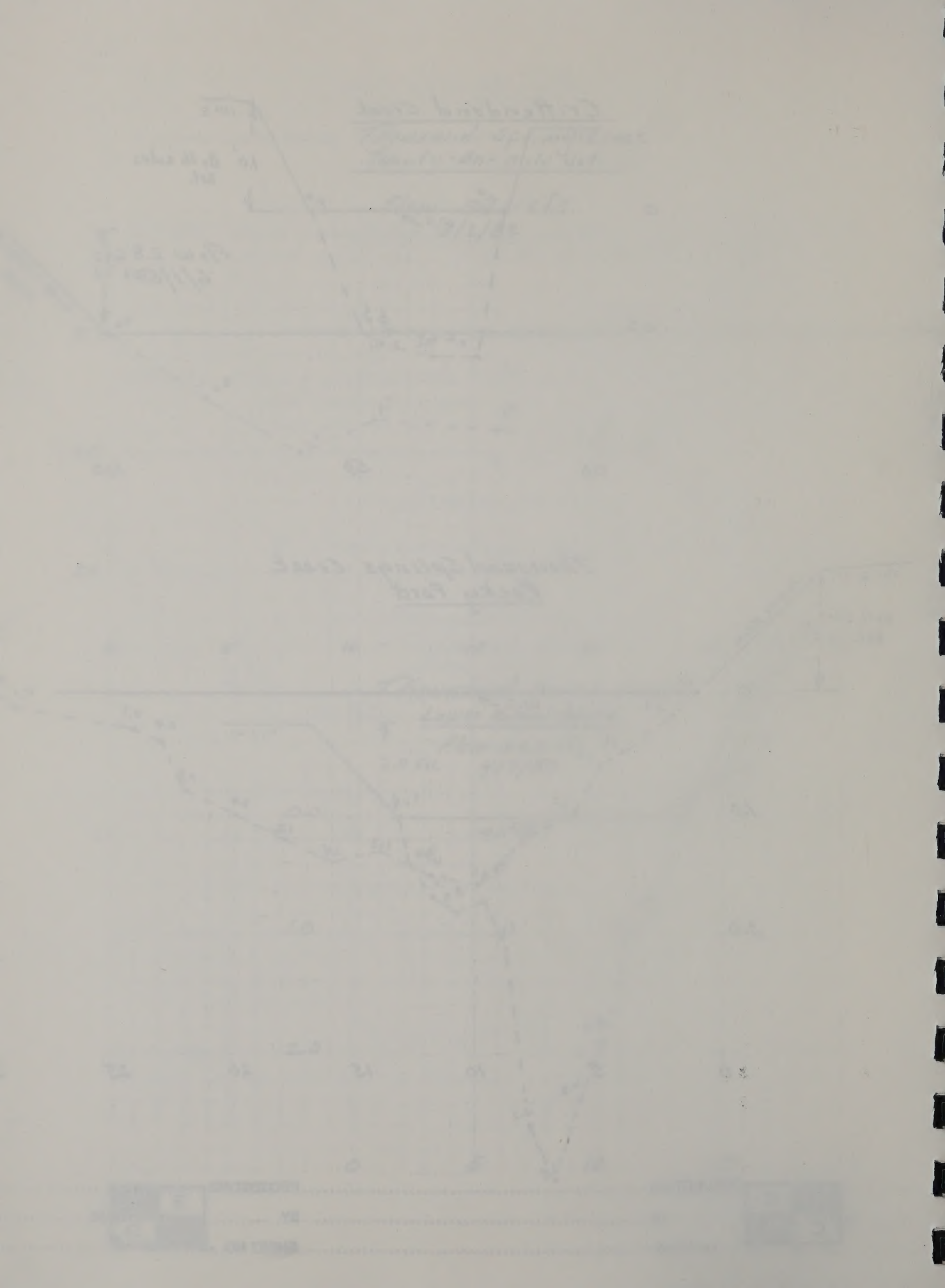
Thousand Springs Creek
Rocky Ford



PROJECT ..... PROJECT NO. .....

..... BY ..... DATE .....

..... SHEET NO. 5 ..... OF 5 .....



APPENDIX C-3

SENSITIVITY ANALYSES RESULTS FOR THE TOANO DRAW NUMERICAL MODEL

SENSITIVITY ANALYSIS

The primary input parameters required by the model were the hydraulic conductivity, the specific yield, and the areal recharge value. Hydraulic conductivity values were initially estimated based on an analysis of pumping tests and surface geophysical surveys (time domain electromagnetic soundings) conducted within the model domain. Specific yield values were estimated based on values quoted in the literature for aquifer materials similar to those occurring in Toano Subbasin. Initial estimates for areal recharge were based on the average annual precipitation (for a 35-year period [1949-1983] as measured at three monitoring stations in the Basin plus 18 years [1963-1980] of monitoring at 23 sites in Rock Spring Creek Subbasin that provided data on orographic effects on precipitation) and the Maxey-Eakin method (see Appendix C-1 for details).

As discussed in Section 8.0, the initial estimates of hydraulic conductivity and areal recharge were adjusted during the model calibration process in order to better simulate existing flows in the modeled aquifer. These calibrated parameter values (referred to as the base case values) were used in the simulations presented in Section 8.0 for eight different pumping scenarios. Due to inherent areal variability in the aquifer hydraulic conductivity, specific yield, and the areal recharge values, as well as the nonunique nature of the calibration process, there is uncertainty associated with the calibrated values.

The sensitivity analysis consisted of individually varying the specific parameters of interest (i.e., hydraulic conductivity, specific yield, and areal recharge) and observing the effect of each change on the behavior of the aquifer over the life of the project (i.e., 49 years) for the Least Environmental Impact Alternative (Case 2B). The input parameters for each run, with the exception of the particular parameter being analyzed, were identical to those used for the base case. For each sensitivity analysis run, the following results were compared with the corresponding base case results:

- Evapotranspiration for three reaches (identified below) of Thousand Springs Creek
- Groundwater discharge to or recharge from three reaches of Thousand Springs Creek
- Water table elevation for Wells MW-4 and TW-15 (located in the northern and southern portion of Toano Draw, respectively)
- Groundwater outflow in the northeast portion of the Basin

Stream Reach I extends from the western (upstream) edge of the model area to Shores, Stream Reach II extends from Shores to Eccles Narrows, and Stream Reach III extends from Eccles Narrows to the eastern (downstream) edge of the model area.

The following paragraphs describe the sensitivity analysis conducted for each parameter.

Effects of Variations in Areal Recharge

Three simulations each using different areal recharge values were conducted to evaluate the sensitivity of the model results to recharge:

- Run R1: The annual recharge was varied based on the historic observed variations in precipitation. Note that the mean annual recharge is the same as for the base case.
- Run R2: The recharge estimated for Case R1 was reduced by 25 percent.
- Run R3: The effect of an extended drought was simulated by reducing the mean annual recharge by 50 percent for 4 years during the period of maximum consumption of water by the proposed power plant. For the rest of the simulation period, the recharge was equal to the mean annual recharge as used in the base case.

Sensitivity Run R1. This model run (Run R1) was conducted to evaluate the effect of year-to-year variation in recharge on the aquifer. The imposed variation of the recharge rate was similar to the observed variation in precipitation for the 35 years from 1949 to 1983. The precipitation record was used to estimate the recharge pattern for the first 35 years of power plant operation and then the first 14 years of the period repeated to estimate recharge for the remaining 14 years of the plant operation. The variation of the ratio of annual precipitation to the long-term mean annual precipitation is shown on Figure C-3.1. These ratios were used to adjust the base case recharge to estimate the yearly recharge values. All other model parameters were identical to the base case. It was anticipated that the results of this run might indicate short-term impacts from the varying recharge but that long-term results would be identical to the base case.

Comparison of the results for Run R1 and the base case are presented on Figures C-3.2 through C-3.6. Evapotranspiration (ET) rate and groundwater discharge rate to and from the river, for stream reaches, indicate no substantial differences between the two runs. Water level fluctuations in Wells MW-4 and TW-15 for both cases, over the life of the project, are nearly identical, differing by less than 1 foot. Groundwater flow out of

the model area for both cases declines about 5 acre-feet/year over the life of the project. The small variations in the results are within the overall accuracy of the model. Hence, it is concluded that the use of a constant value of areal recharge based on the long-term average precipitation is reasonable.

Sensitivity Run R2. For this run, the areal recharge used for Sensitivity Run R1 was reduced by 25 percent. All other model parameters were the same as those used for the base case (pumping scenario Case 2B).

A comparison of the results of Run R2 and the base case indicates that the ET rate and groundwater discharge rate to or from the river do not differ substantially (Figures C-3.7 through C-3.11). ET for Run R2 is virtually identical to the base case for Stream Reaches I and II and differs by less than 40 acre-feet/year for Stream Reach III. The results for groundwater discharge to or from the river are similar, with flow to Stream Reach III about 90 acre-feet/year less for Run R2 than for the base case. At the end of the project (Year 49), the water level in MW-4 is about 2 feet lower for Run R2 than for the base case. In TW-15, the maximum difference in water level between the two runs is about 3 feet. In Year 49, groundwater discharge for Run R2 is about 8 acre-feet/year less than for the base case. These small differences are within the accuracy of the model and, therefore, it is concluded that the model is relatively insensitive to a decrease in recharge rate of 25 percent.

Sensitivity Run R3. This model run was conducted to evaluate the effect on the aquifer of an extended drought over a 4-year period in the project life when pumpage is at a maximum. This 4-year drought was simulated by reducing the recharge by 50 percent of the long-term average value used for the base case following the start of the eighth unit (i.e., beginning in Year 15). Recharge during all other years was specified as the long-term average value. All other model parameters were identical to those for the base case. This simulation is believed to be conservative because

historical records indicate that such a drought period has not occurred during the 35-year period for which precipitation records are available.

The results of Run R3 are essentially identical to the results of the base case. Evapotranspiration rates differ by less than about 10 acre-feet/year for the three Stream Reaches (Figure C-3.12). The maximum difference in groundwater discharge rate to or from the river is less than 20 acre-feet/year (Figure C-3.13). Groundwater levels in Wells MW-4 and TW-15 are within 1 foot for the two runs over the life of the project (Figures C-3.14 and C-3.15). Groundwater outflow from the model area for the two runs is within a few acre-feet/year (Figure C 3.16). Based on these results, it can be concluded that an extended period of drought (greater than that observed in the 35-year historic precipitation record for the Basin) would not result in groundwater levels substantially different than those predicted by the base case at the end of the project.

Effects of Variations in Specific Yield

Two runs were conducted to evaluate the sensitivity of the aquifer to the specific yield values. Recall that for the base case, a constant value of 0.1 was assigned to the entire model domain. The sensitivity run included:

- Run SY1 specific yield values of 0.1 and 0.05 were assigned to the alluvial aquifer and alluvial fan-volcaniclastic aquitard, respectively.

- Run SY2 specific yield values of 0.2 and 0.05 were assigned to the alluvial aquifer and alluival fan-volcaniclastic aquitard, respectively.

Sensitivity Run SY1. For this run, specific yield values of 0.1 and 0.05 were assigned to the alluvial materials and volcaniclastic rocks, respectively. All other parameters were identical to the base case values.

A comparison of the results of Run SY1 with the base case indicates no substantial difference between the results of the two simulations. ET rates are within about 15 acre-feet/year for the two cases (Figure C-3.17). Groundwater discharge to the river is slightly less for Run SY1 than for the base case but is within about 50 acre-feet/year of the base case values (Figure C-3.18). Water levels are slightly lower for Run SY1 than the base case and differ by less than 1 foot in MW-4 and by less than 4 feet in TW-15 (Figures C-3.19 and C-3.20). Groundwater flow from the model area is slightly less in Run SY1 by a few acre-feet/year (Figure C-3.21). Note that these differences are within the accuracy of the model. Thus, it is concluded that the use of a single value of specific yield (0.1) for both aquifer materials or the use of multiple values (0.1 and 0.05) does not significantly change the model results.

Sensitivity Run SY2. This run was conducted to evaluate the sensitivity of the model to the value of specific yield assigned to the alluvial aquifer materials. For this run, the value of specific yield for the alluvial materials was doubled from that used in Run SY1, i.e. from 0.1 to 0.2. The value of specific yield for the volcaniclastics was 0.05. All other model parameters were identical to the base case.

A comparison of the results of this run with the results of the base case indicates that the model is sensitive to a change in specific yield for the alluvial materials. The reduction in ET for Run SY2 is less than Run SY1 by about 130 acre-feet/year in Stream Reach I and by about 40 acre-feet/year in Stream Reach II (Figure C-3.22). Figure C-3.23, which shows groundwater discharge to or from the three Stream Reaches, indicates that flow to the river in Reach I at the end of the project life (Year 49) is about 500 acre-feet/year greater if a specific yield of 0.2 is used instead of 0.1. Figures C-3.24 and C-3.25 compare the results of Run SY2 and the base case for water levels in Wells MW-4 and TW-15 and indicate that maximum drawdown during the life of the project (49 years) is about 9 feet

less in MW-4 and about 30 feet less in TW-15 when a specific yield value of 0.2 is used instead of a value of 0.1. Groundwater flow from the model area is essentially the same for the two cases, differing by only a few acre-feet/year (Figure C-3.26).

These results indicate that the model is sensitive to the specific yield value specified for the alluvial aquifer and that selection of an accurate value for specific yield is important in obtaining accurate results. The value of 0.1 used for the base case is believed to be a conservative estimate for specific yield in these types of aquifer materials. As discussed in Section 8.3, estimates for specific yield in these types of deposits range from 0.1 to 0.3. Based on this, 0.1 is the lower limit of expected specific yield and represents a conservative estimate. The actual value of specific yield may be higher, in which case the drawdowns would be less than the drawdowns predicted for the base case.

Smoothing of Hydraulic Conductivity

The apparent discontinuities in the base case hydraulic conductivity values in adjacent nodes, shown on Figure C.3-27, could result in unrealistic results. Therefore, a final sensitivity run (HC1) was conducted by smoothing the calibrated (base case) hydraulic conductivity values.

Senstivity Run HC1: The results of Run HC1 were calibrated against the observation well data to evaluate whether smoothing the hydraulic conductivity distribution significantly affected the match between model simulated heads and measured heads. Figure C-3.28 shows a plot of measured versus simulated water table elevation. A linear regression performed on the results gave the following equation:

$$y = 33 + 0.99x \qquad (8\text{-}1)$$

where

y = simulated water table elevation [feet]
x = measured water table elevation [feet]

The correlation coefficient for this regression is 98 percent. The results showed that in three of the observation wells, the match between the measured and simulated water table elevations became worse whereas slight improvement was achieved in other wells. It should be noted that water level elevations within the alluvial aquifer did not change substantially due to the smoothing of hydraulic conductivities.

The results of Run HC1 were compared to the results of the transient simulation of 49 years using base case values for the pumping alternative. These results are compared on Figures C-3.29 through C-3.33. The evapotranspiration rate for Stream Reach I in Run HC1 is about 100 acre-feet/year less than that for the base case. The ET rate for Stream Reach II for Run HC1 is greater than that for the base case by about 40 acre-feet/year. Groundwater discharge to the river in Reach III is higher for HC1 than for the base case by about 20 acre-feet/year. Water levels in MW-4 and TW-15, when corrected for the new initial head distribution, are within a few feet for the two runs. Groundwater flow rate out of the model area is within a few acre-feet/year for the two runs. Based on these results, it was concluded that the differences between the results of Run HC1 and the base case are within model accuracy and that the calibrated values of hydraulic conductivity distribution used in the base case are reasonable.

Conclusions

Table C-3.1 summarises the results of sensitivity analyses. The sensitivity analyses indicate that, with the exception of a change in the magnitude of specific yield of the alluvial formation, realistic variations of areal recharge, and hydraulic conductivity do not yield results which are substantially different from the the base case results. Sensitivity

analysis of specific yield for the alluvial formation indicate that the model is sensitive to the magnitude of this parameter. However, it is not sensitive to the differences in the specific yield values specified for the volcaniclastics as described above. This is because the volcanics represent less than 5 percent of the volume of aquifer material in the model area. Although the use of a value of 0.2 for specific yield of the alluvial aquifer produces results significantly different from those for the base case, the difference reduces the impact of the proposed project on the groundwater system. Use of the base case specific yield value of 0.1 is believed to result in a conservative (higher than expected) estimate of impacts to the Subbasin.

The sensitivity analysis on the recharge did not produce results substantially different from the base case runs. This is because the annual recharge is much smaller than the volume of water in storage. In transient simulations, most of the water pumped is from aquifer storage.

in addition, the estimated average annual recharge to the basin is only 8300 acre-feet and the total area of the model area (excluding that occupied by the Paleozoic rock outcrops) is 350 square miles. Assuming that the recharge is uniformly distributed over the model area, the average annual recharge over the basin is only about 0.5 inches. For a specific yield of 0.1, the rise in groundwater level from recharge will be only 5 inches per year, which is insignificant with respect to the drawdowns in the basin.

Table C-3.1. COMPARISON OF SENSITIVITY RESULTS TO BASE CASE AT THE END OF PLANT LIFE FOR PUMPING SCENARIO 2B

Sensitivity Case**	Reduction in Evapotranspiration Due to Pumping (ac-ft/yr)				Reduction in Discharge to River Due to Pumping (cc-ft/yr)				Reduction in Groundwater Ouflow Due to Pumping (ac-ft/yr)	Drawdown* (ft)	
	Reach** 1	Reach 2	Reach 3	Total*	Reach 1	Reach 2	Reach 3	Total*		TW-15	MW-4
Base	236	58	35	300	873	60	109	1000	<10	90	15
R1	237	59	40	300	864	63	120	1000	<10	90	15
R2	257	69	73	400	925	87	195	1200	<10	100	15
R3	233	57	37	300	857	61	110	1000	<10	90	15
SY1	247	62	50	400	912	66	156	1100	<10	95	15
SY2	103	21	7	100	394	24	18	400	<10	65	5
HC1	150	95	37	300	777	54	130	1000	<10	90	15

* Total flows have been rounded off to the nearest 100 acre-feet and drawdowns have been rounded off to the nearest 5 feet.

** See text for extent of each reach and details of sensitivity case.

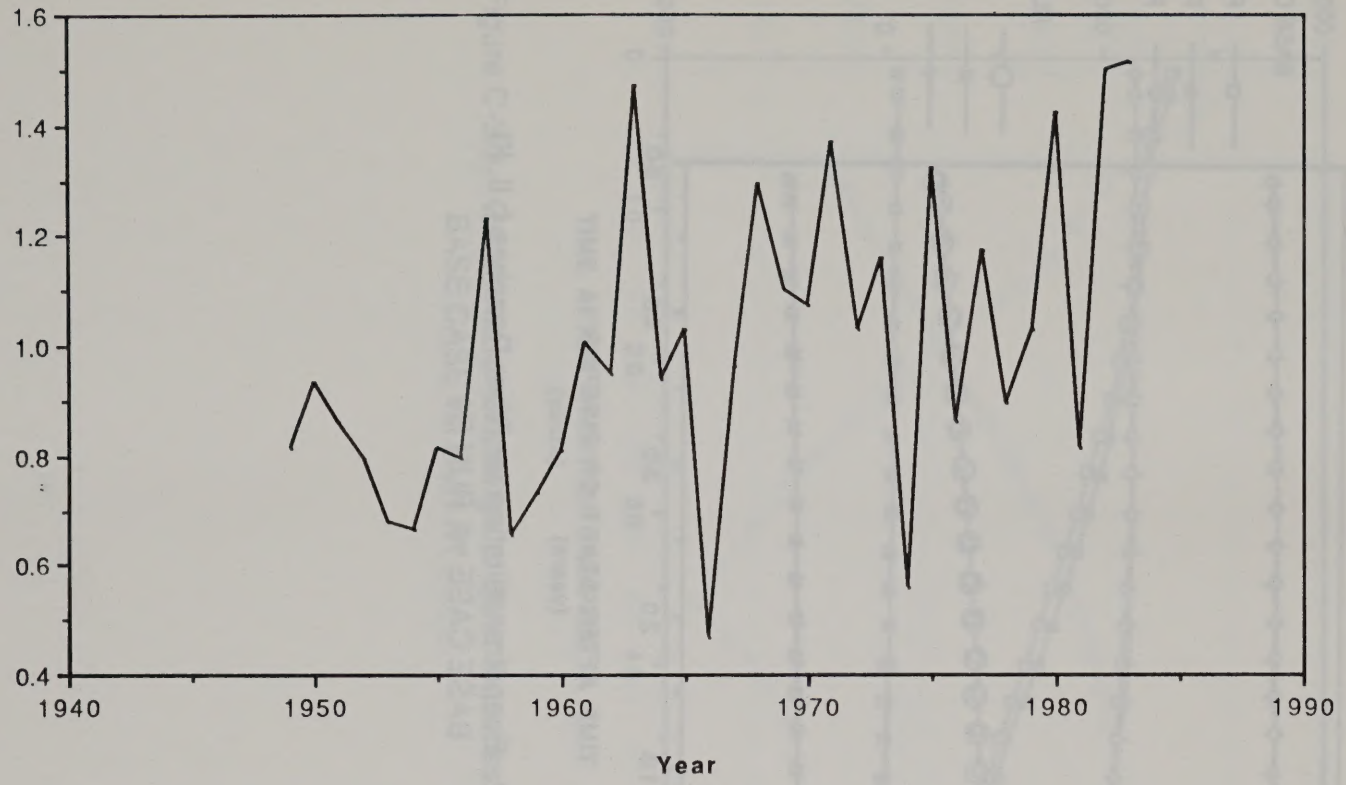


Figure C-3.1. Variation of Annual Precipitation with Time

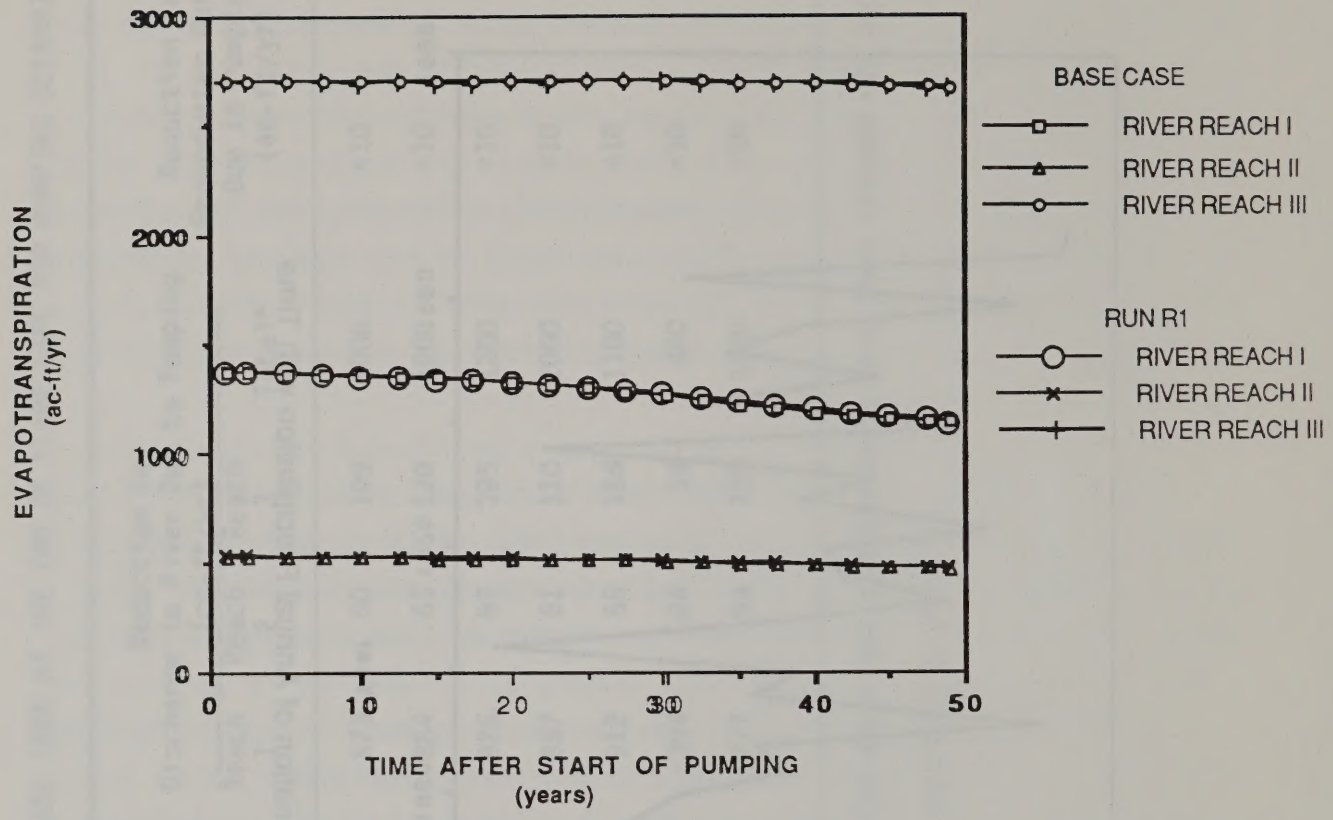


Figure C-3.2. Evapotranspiration for River Reaches I, II, III
BASE CASE vs. RUN R1

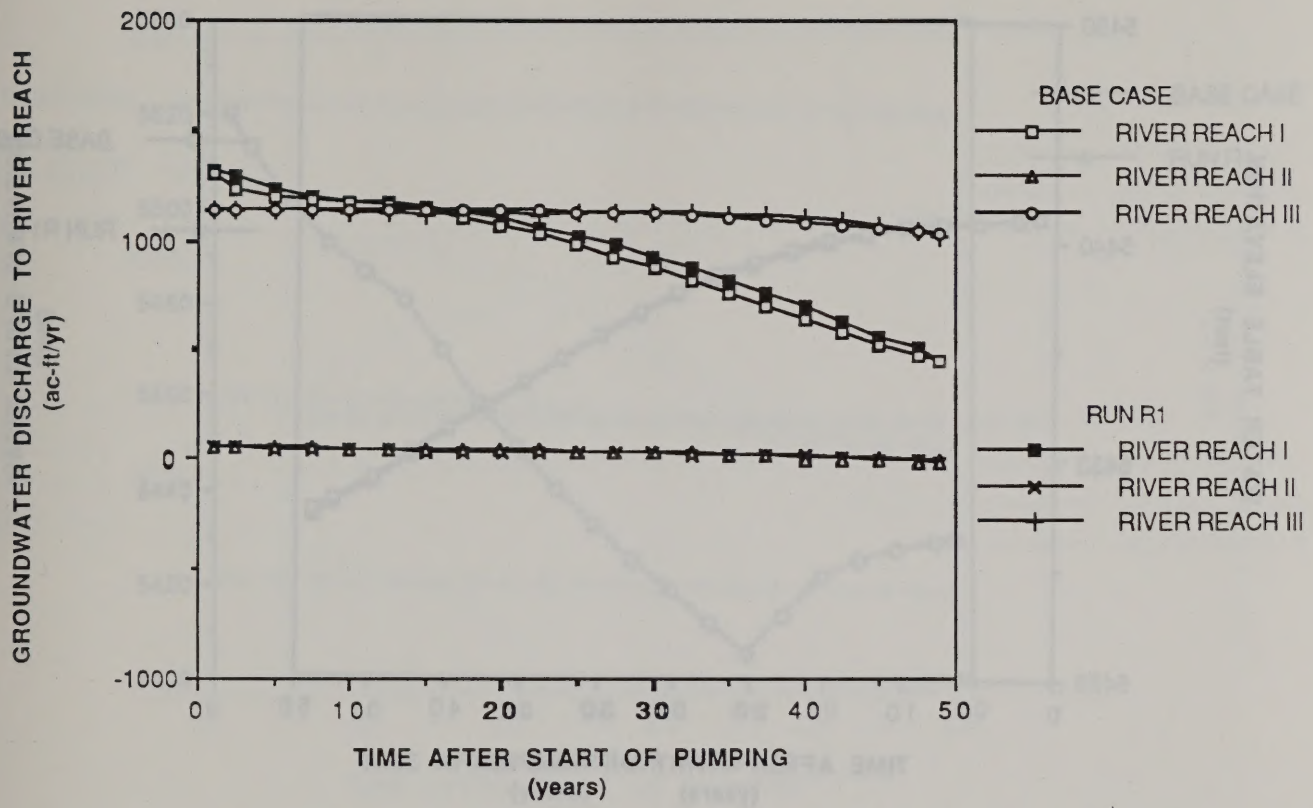


Figure C-3.3. Groundwater Discharge to River Reaches I, II, III
BASE CASE vs. RUN R1

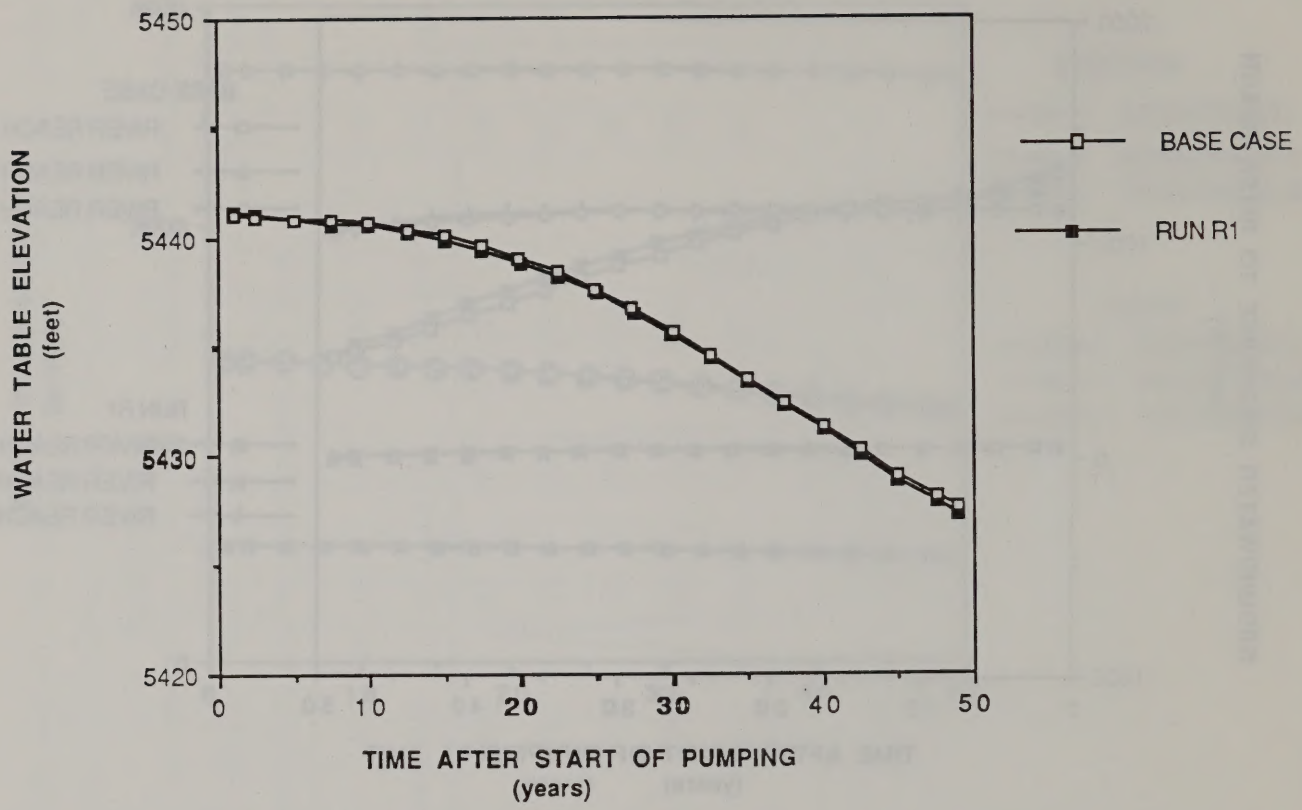


Figure C-3.4. Water Level vs. Time for MW-4
BASE CASE vs. RUN R1

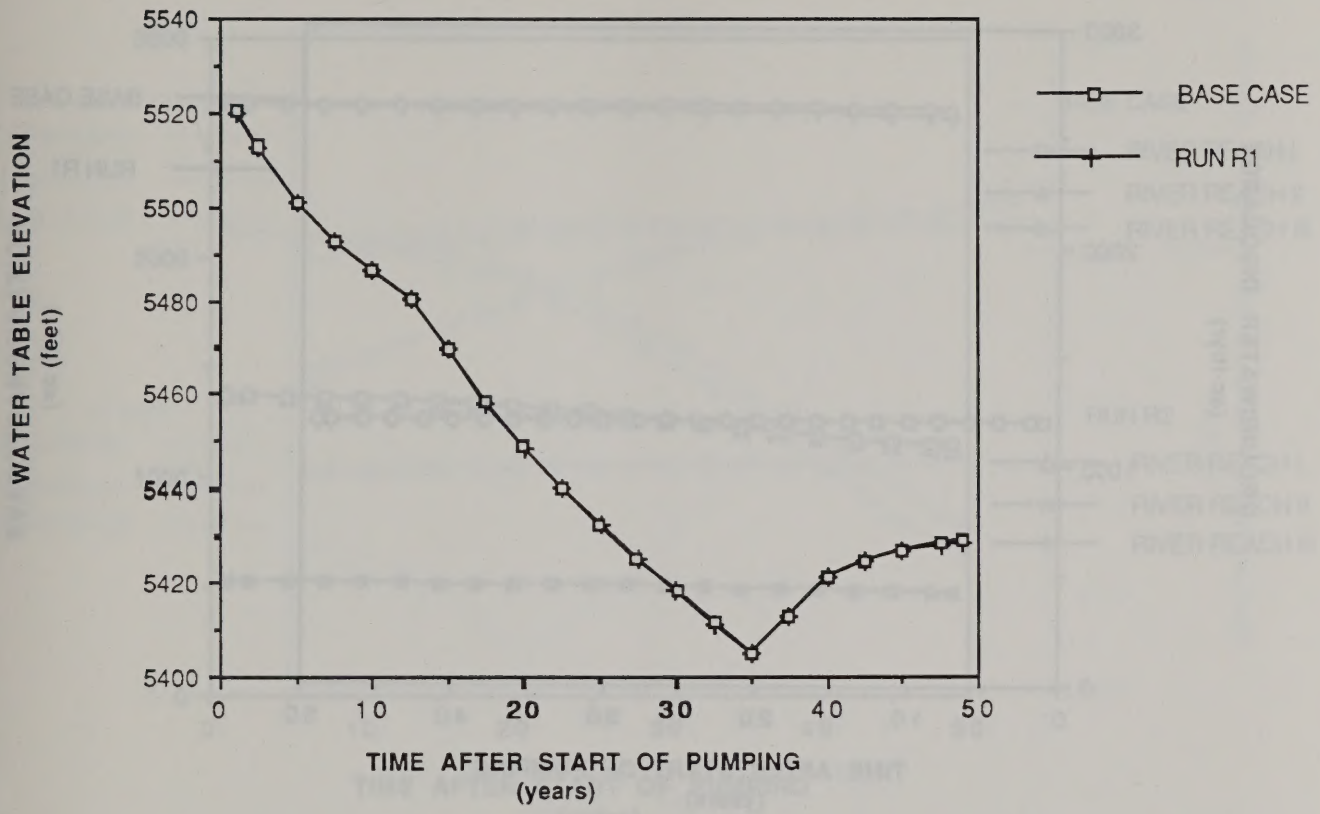


Figure C-3.5. Water Level vs. Time for TW-15
BASE CASE vs. RUN R1

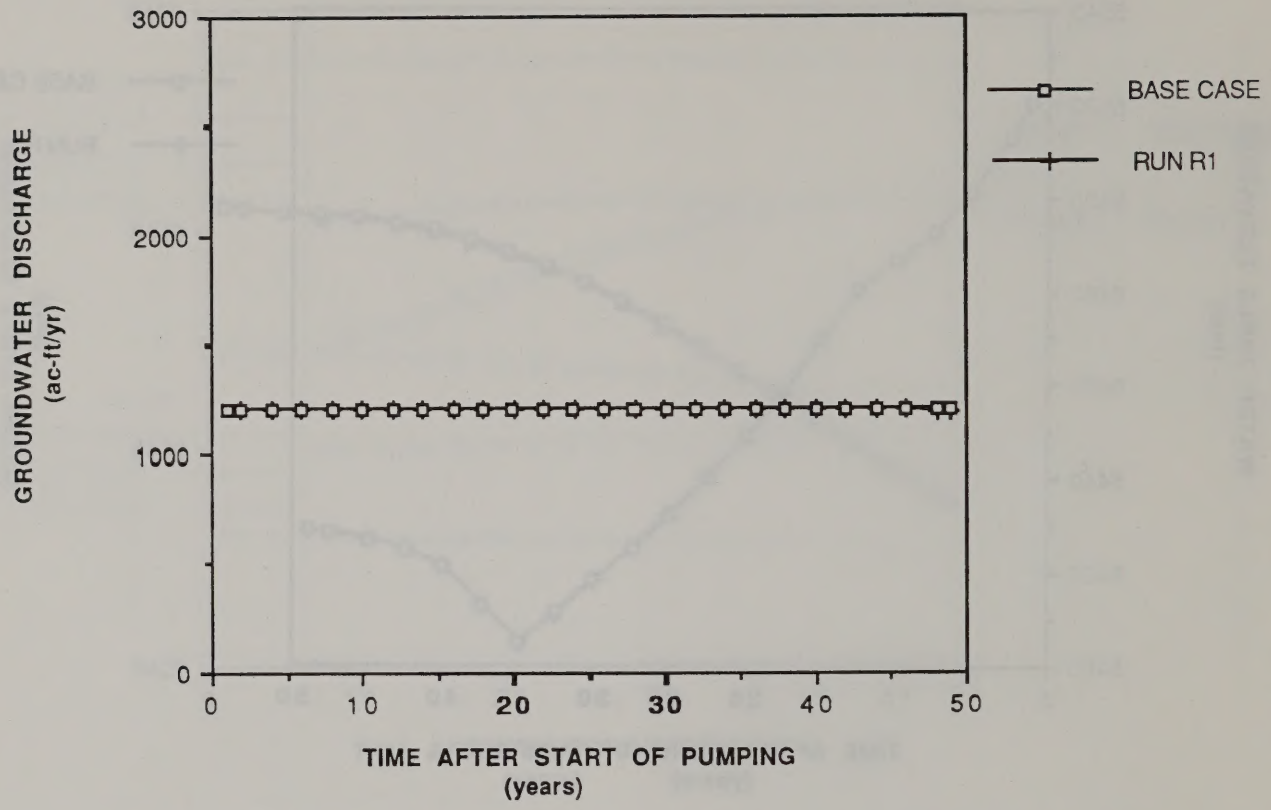


Figure C-3.6. Groundwater Flow from Model Area
BASE CASE vs. RUN R1

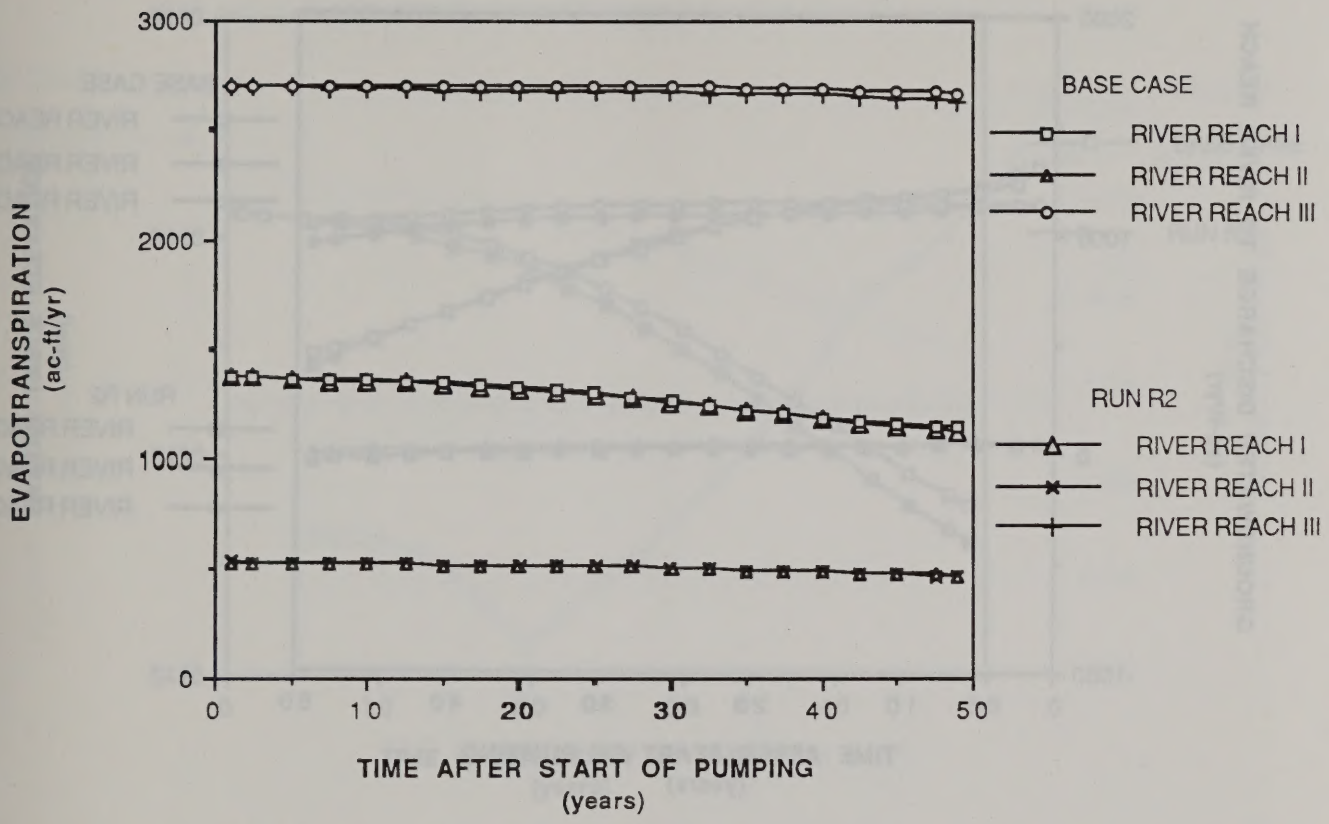


Figure C-3.7. Evapotranspiration for River Reaches I, II,III
BASE CASE vs. RUN R2

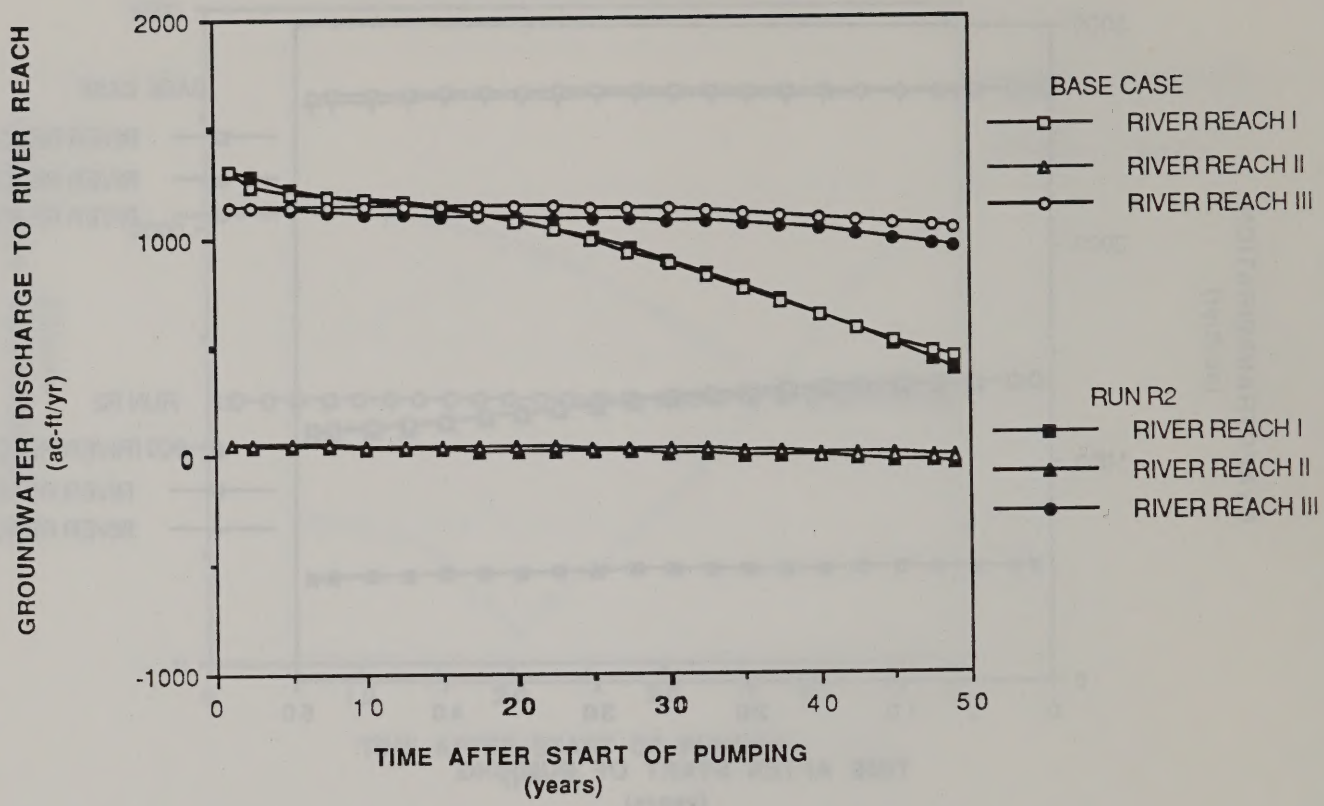


Figure C-3.8. Groundwater Discharge to River Reaches I, II, III
BASE CASE vs. RUN R2

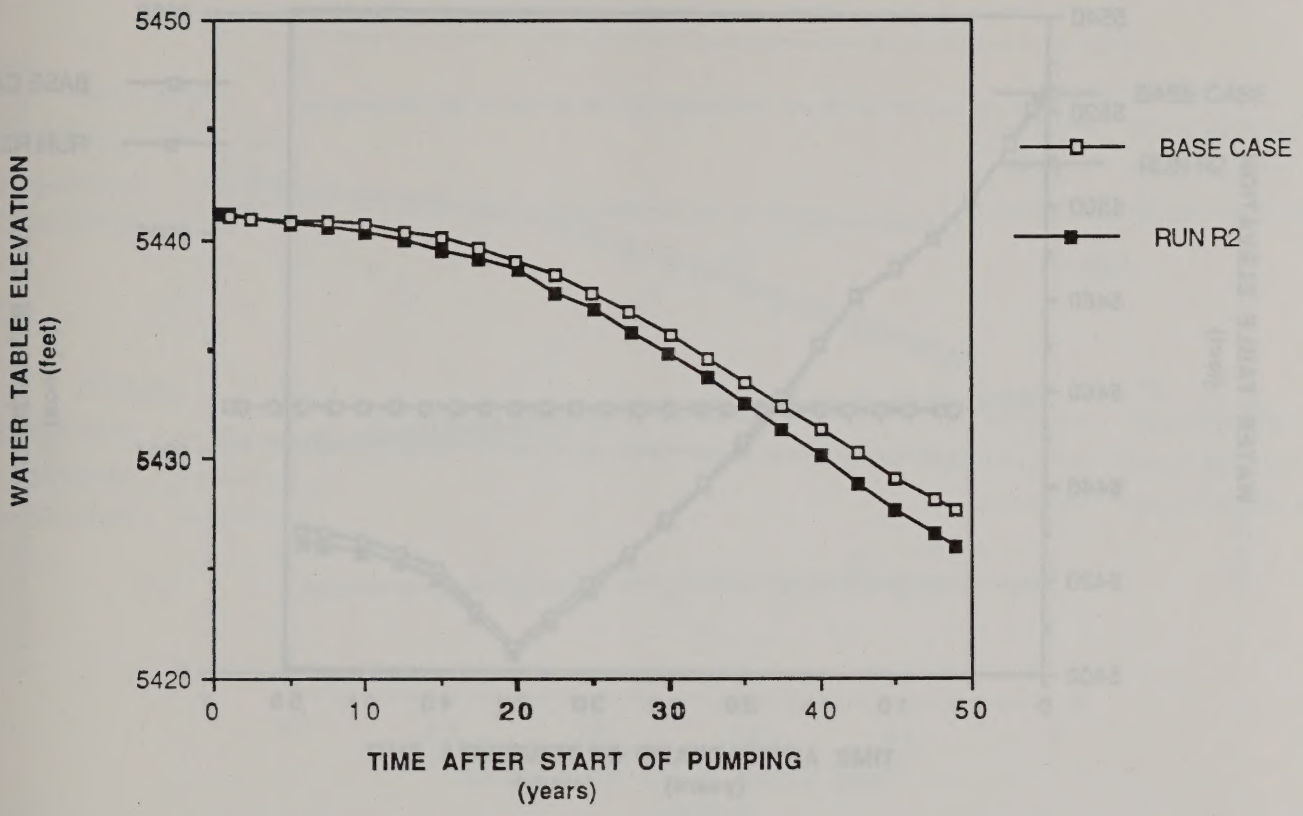


Figure C-3.9. Water Level vs, Time for MW-4
BASE CASE vs. RUN R2

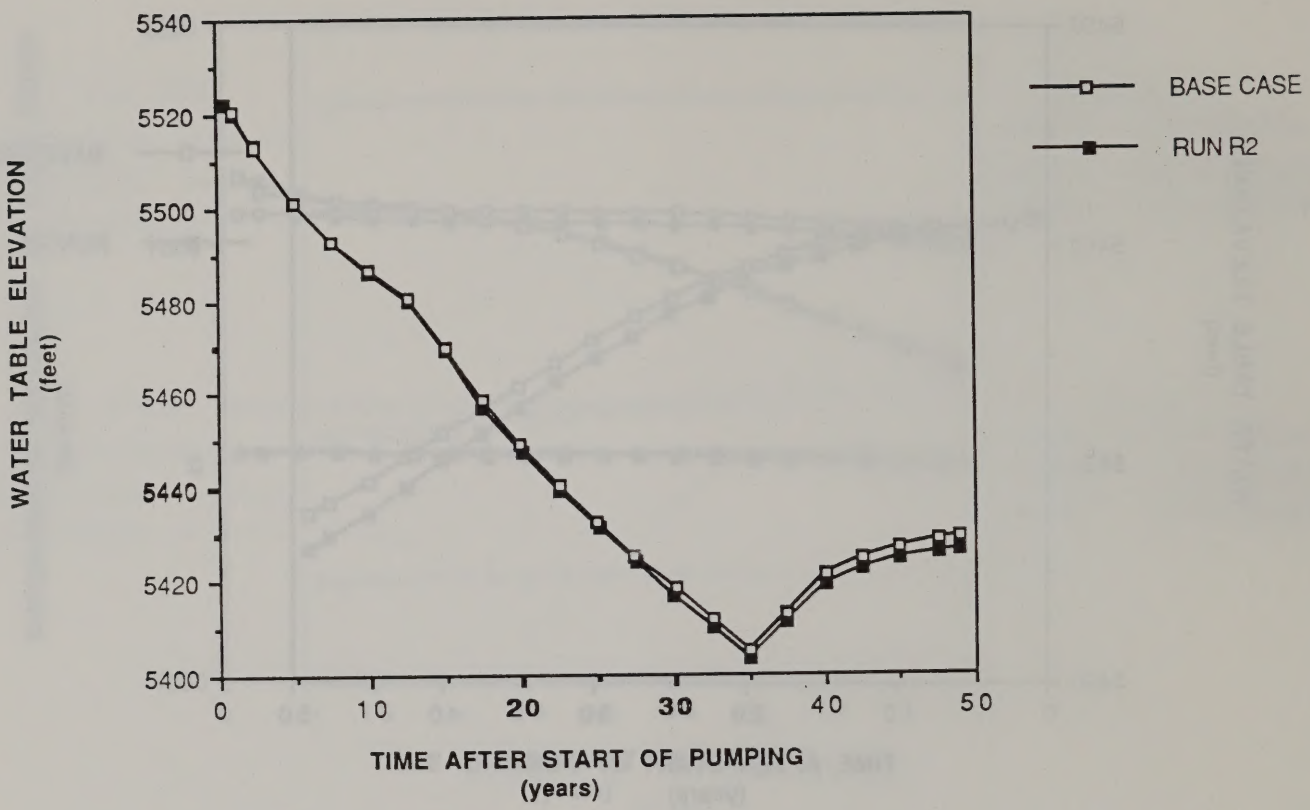


Figure C-3.10. Water Level vs. time for TW-15
BASE CASE vs. RUN R2

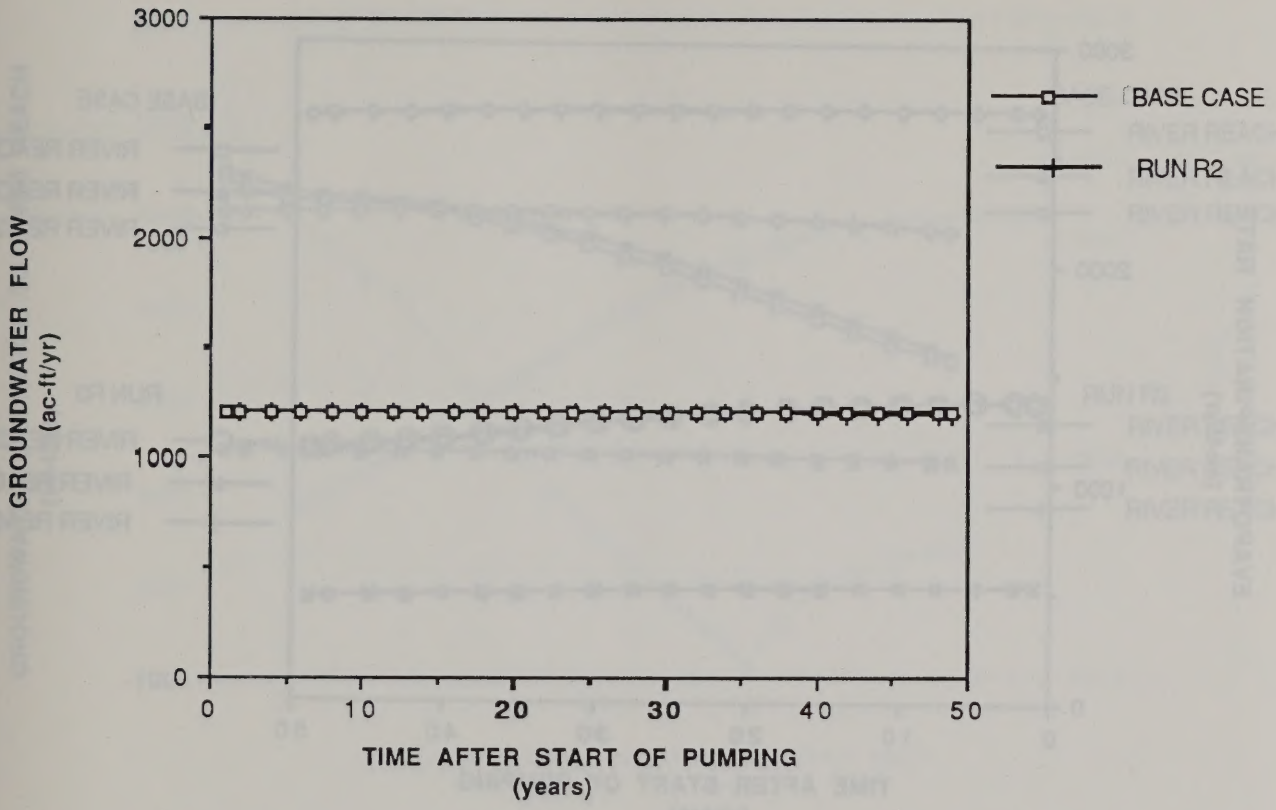


Figure C-3.11. Groundwater Flow from Model Area
BASE CASE vs. RUN R2

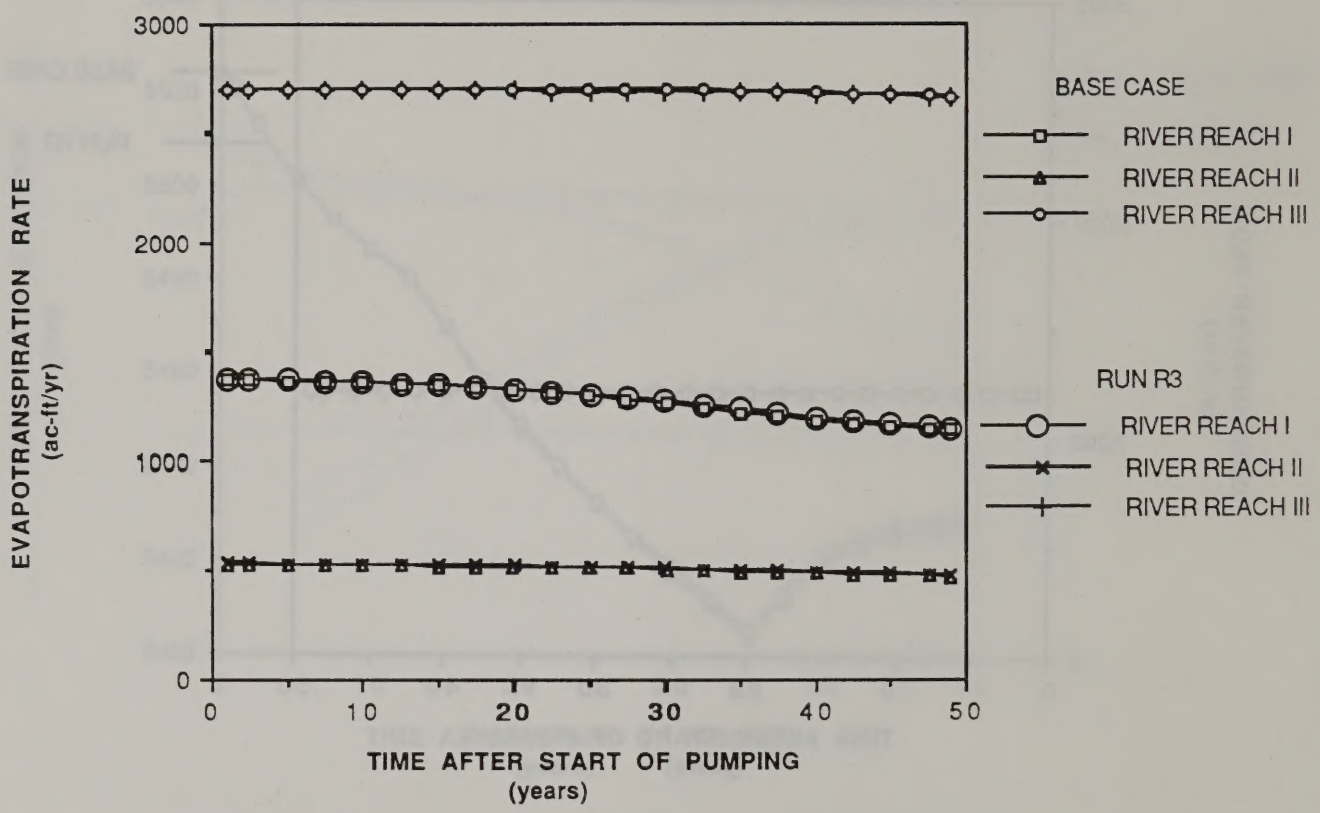


Figure C-3.12. Evapotranspiration for River Reaches I, II,III
BASE CASE vs. RUN R3

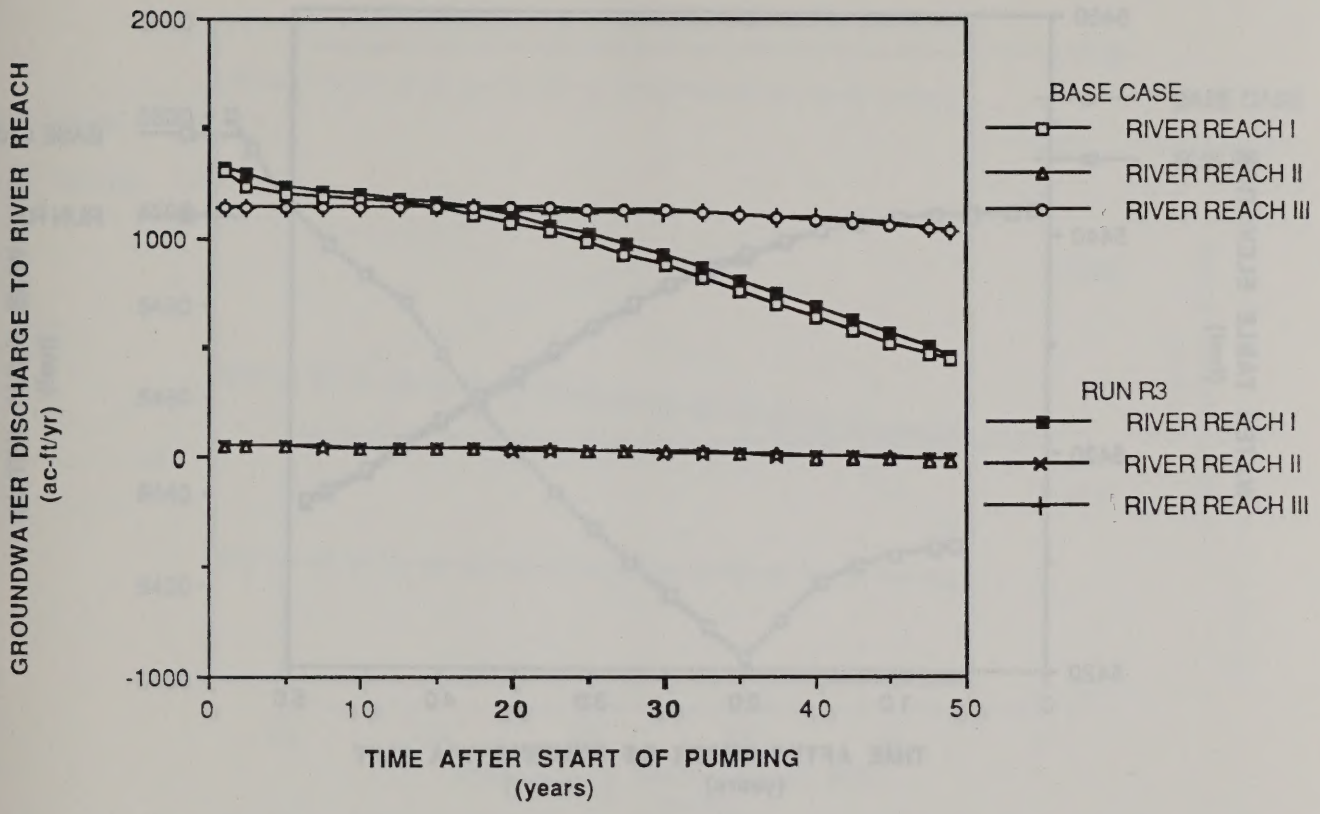


Figure C-3.13. Groundwater Discharge to River Reaches I, II, III
BASE CASE vs. RUN R3

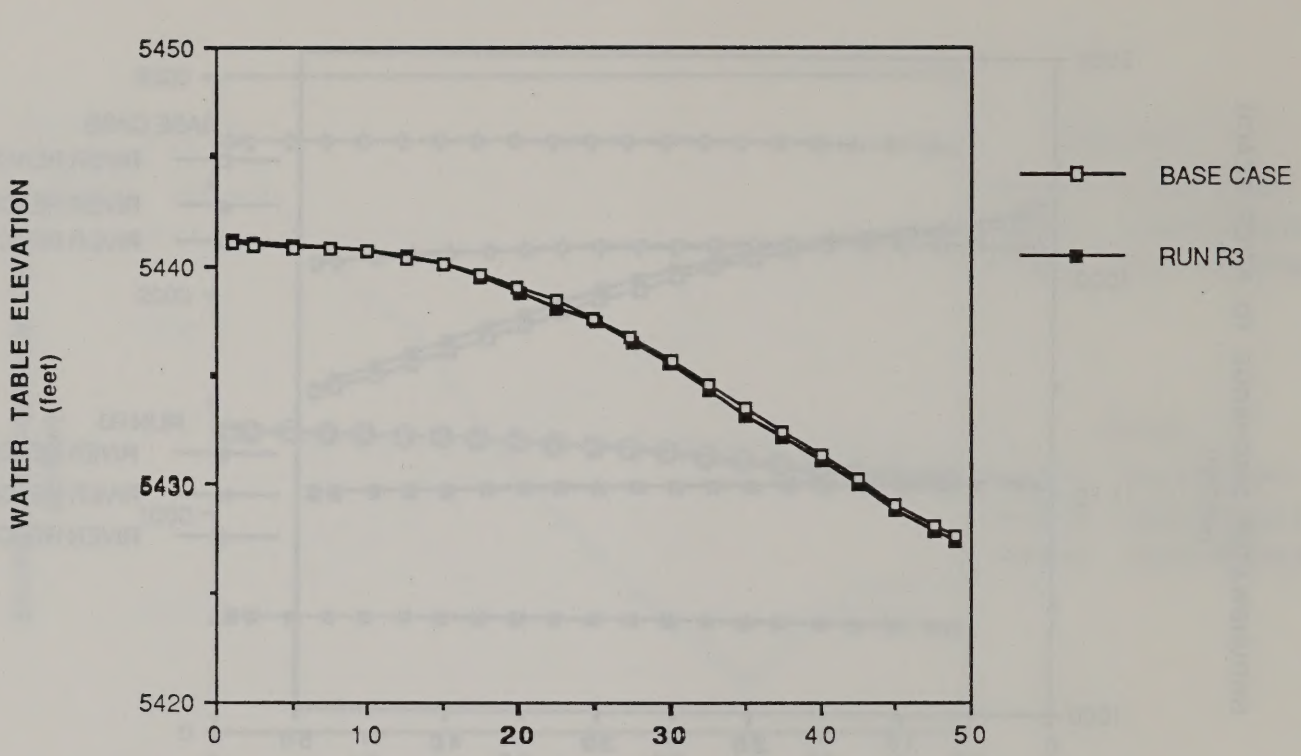


Figure C-3.14. Water Level vs. Time for MW-4
BASE CASE vs. RUN R3

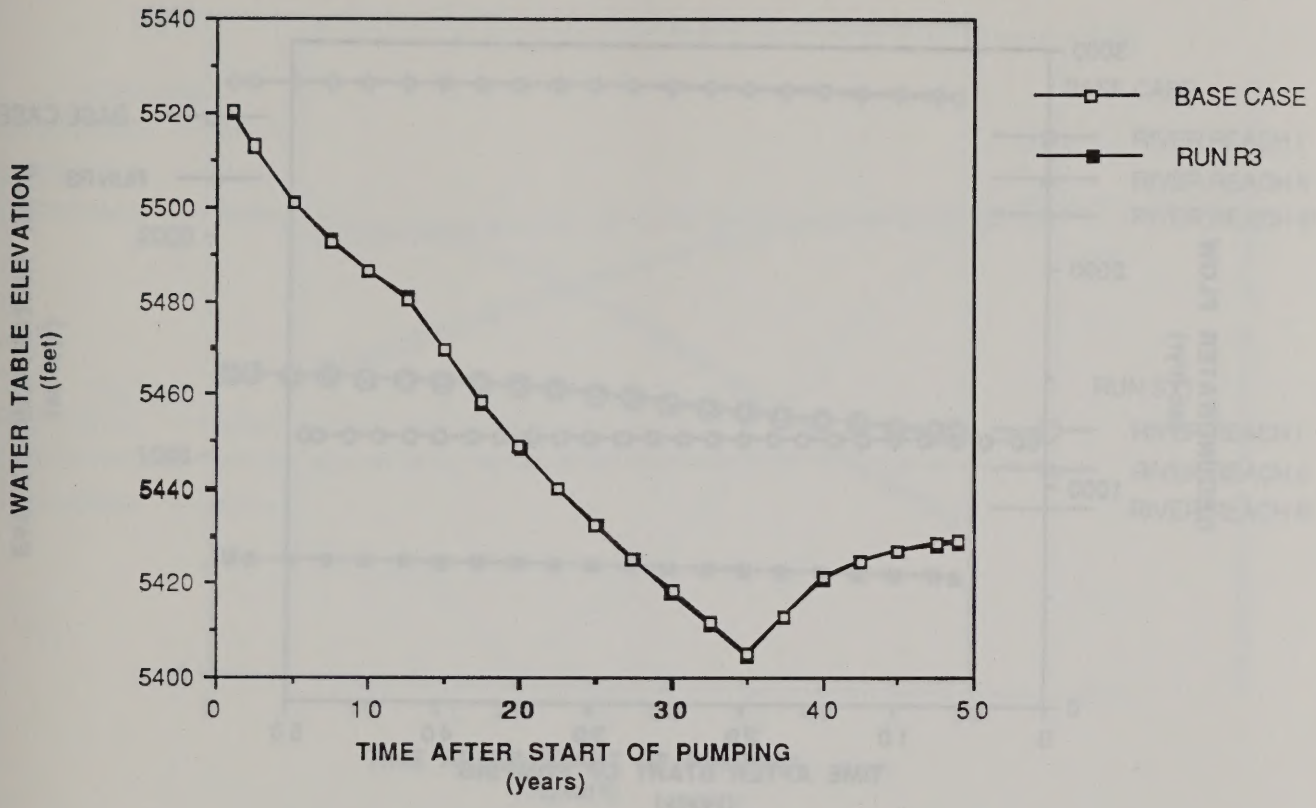


Figure C-3.15. Water Level vs. Time for TW-15
BASE CASE vs. RUN R3

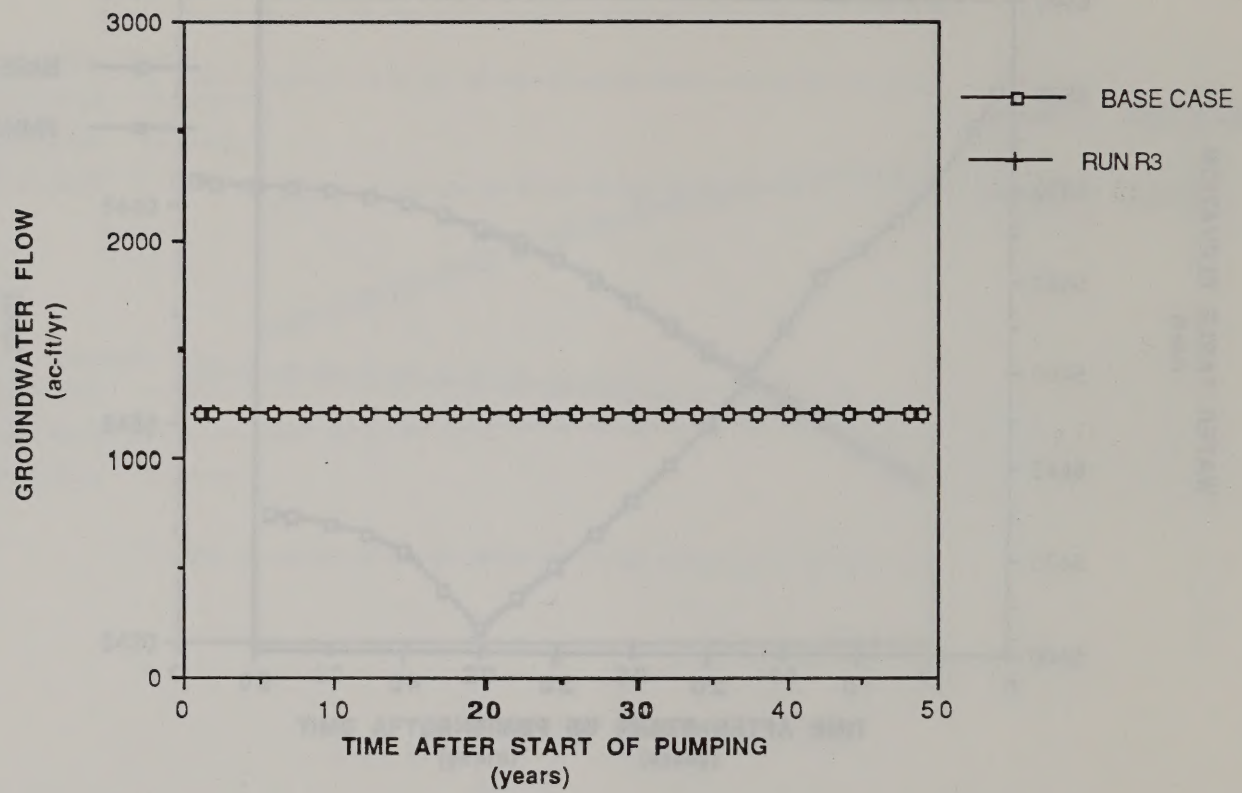


Figure C-3.16. Groundwater Flow from Model Area
BASE CASE vs. RUN R3

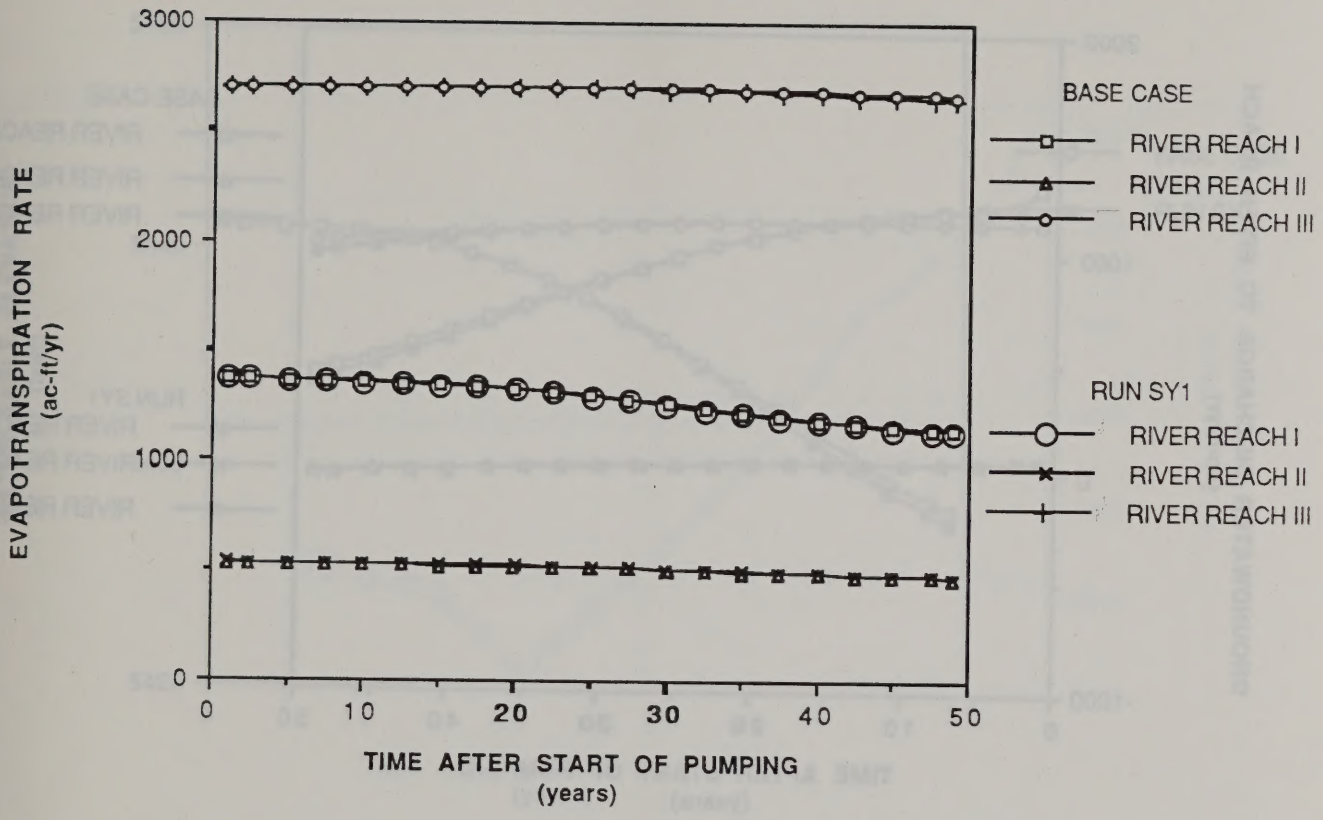


Figure C-3.17. Evapotranspiration for River Reaches I, II, III
BASE CASE VS. RUN SY1

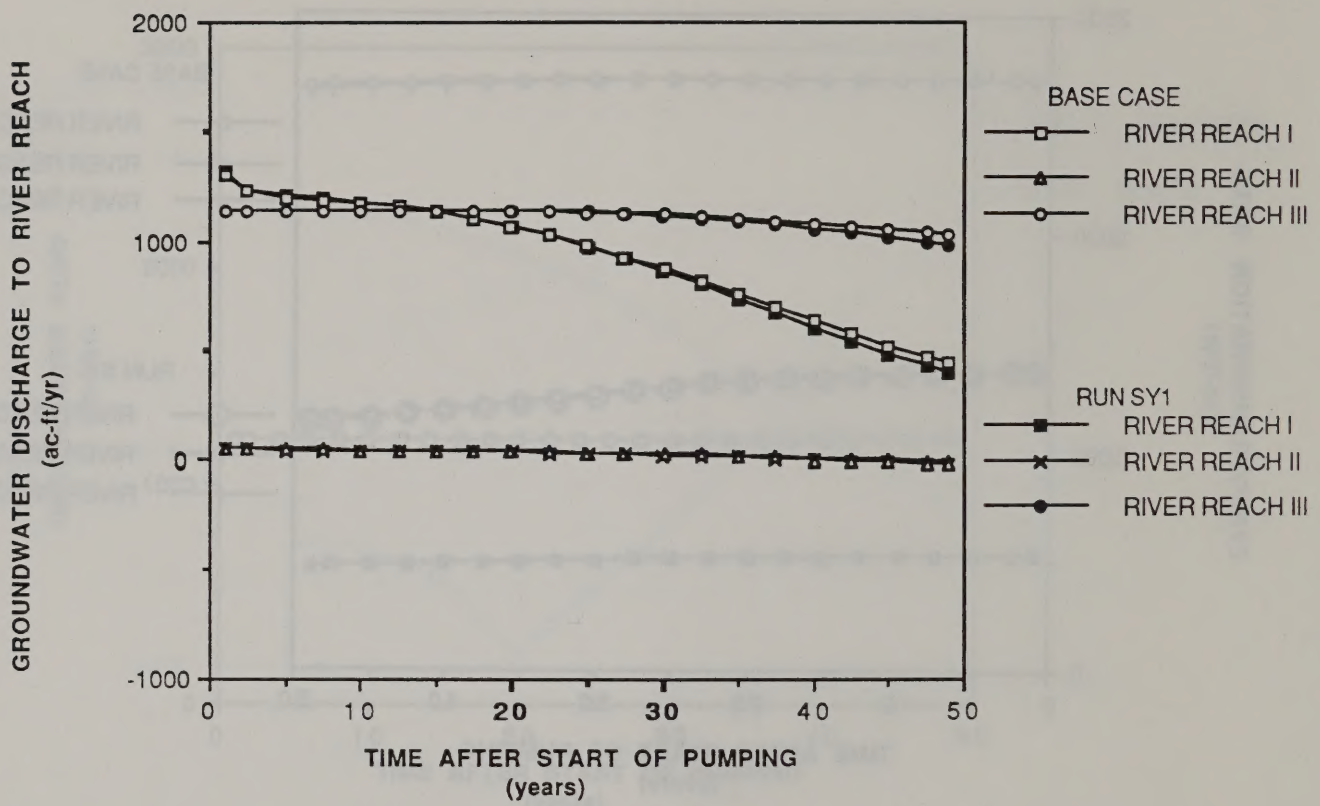


Figure C-3.18. Groundwater Discharge to River Reaches I, II, III
BASE CASE vs. RUN SY1

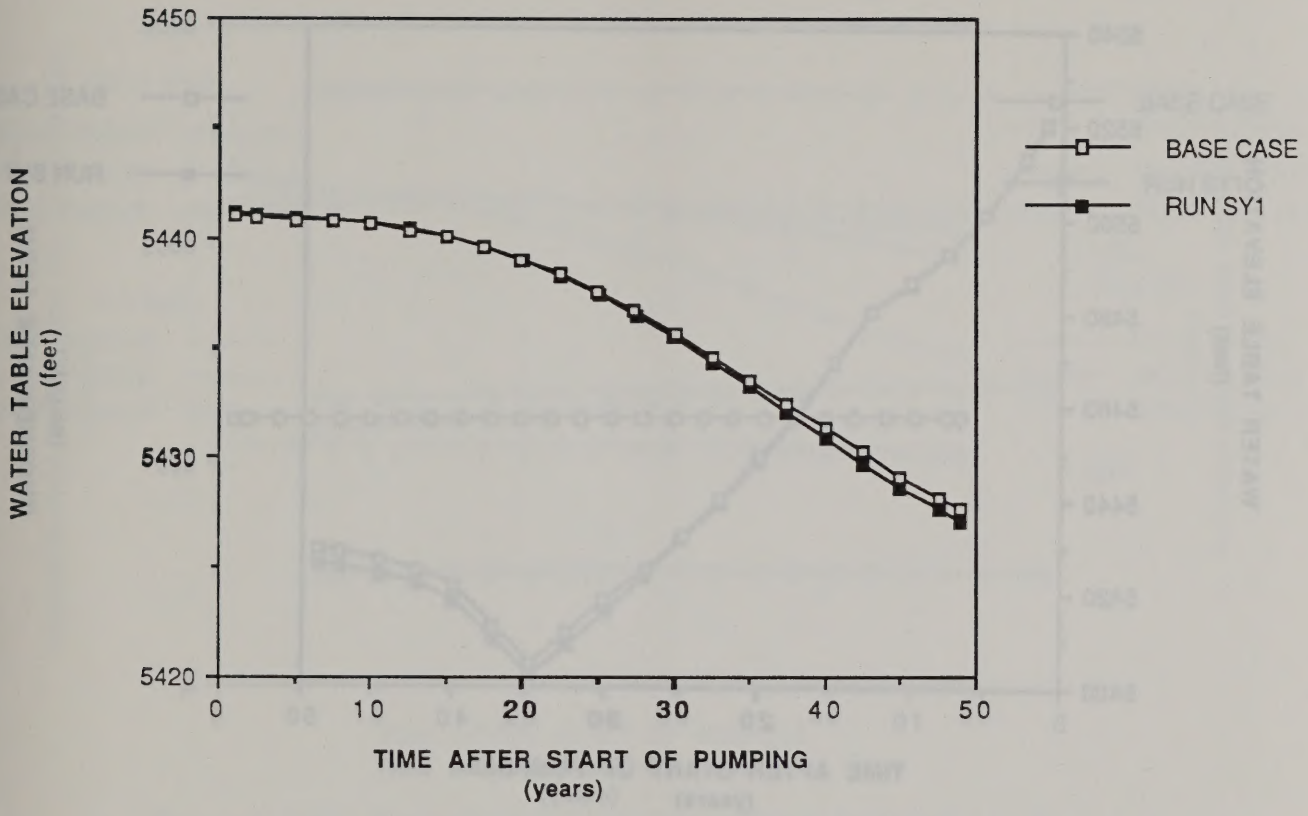


Figure C-3.19. Water Level vs. Time for MW-4
BASE CASE vs. RUN SY1

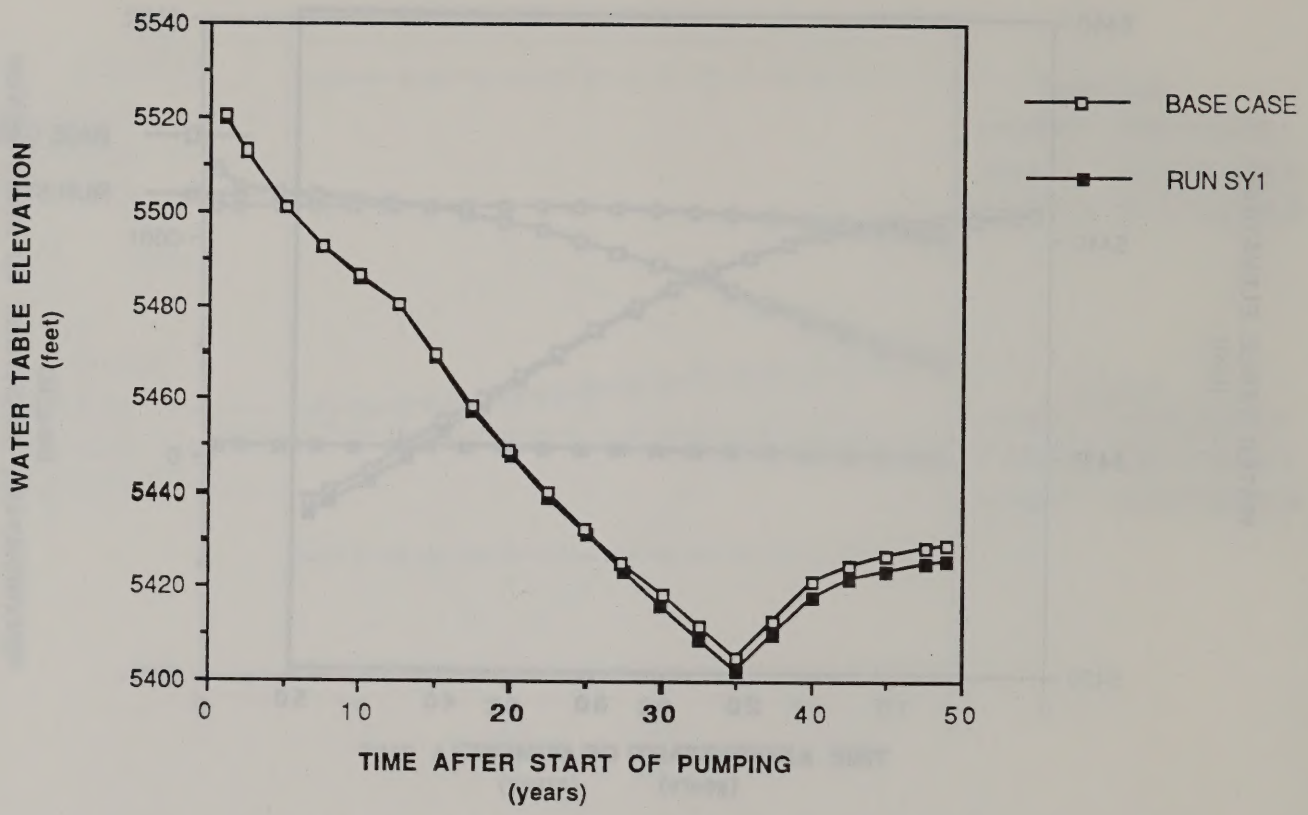


Figure C-3.20. Water Level vs. Time for TW-15
BASE CASE vs. RUN SY1

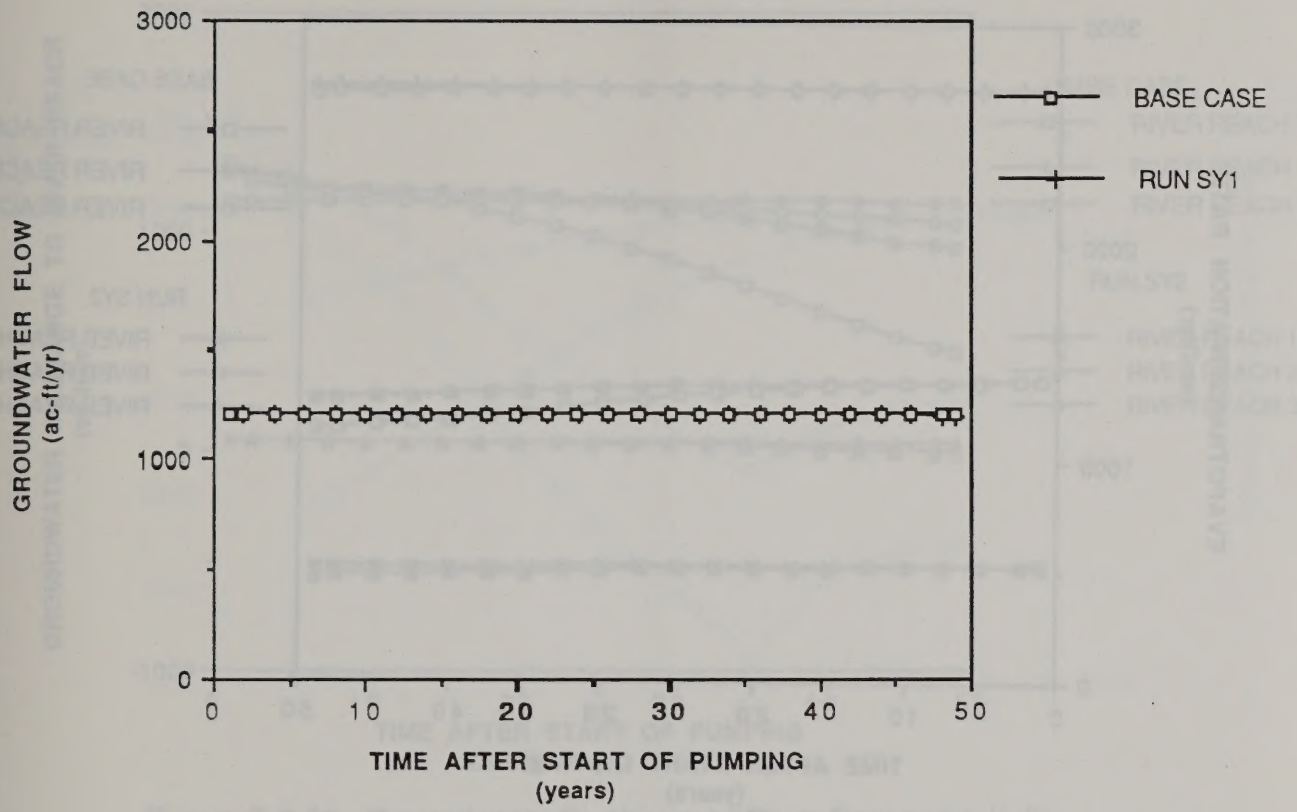


Figure C-3.21. Groundawter Flow from Model Area
BASE CASE vs. RUN SY1

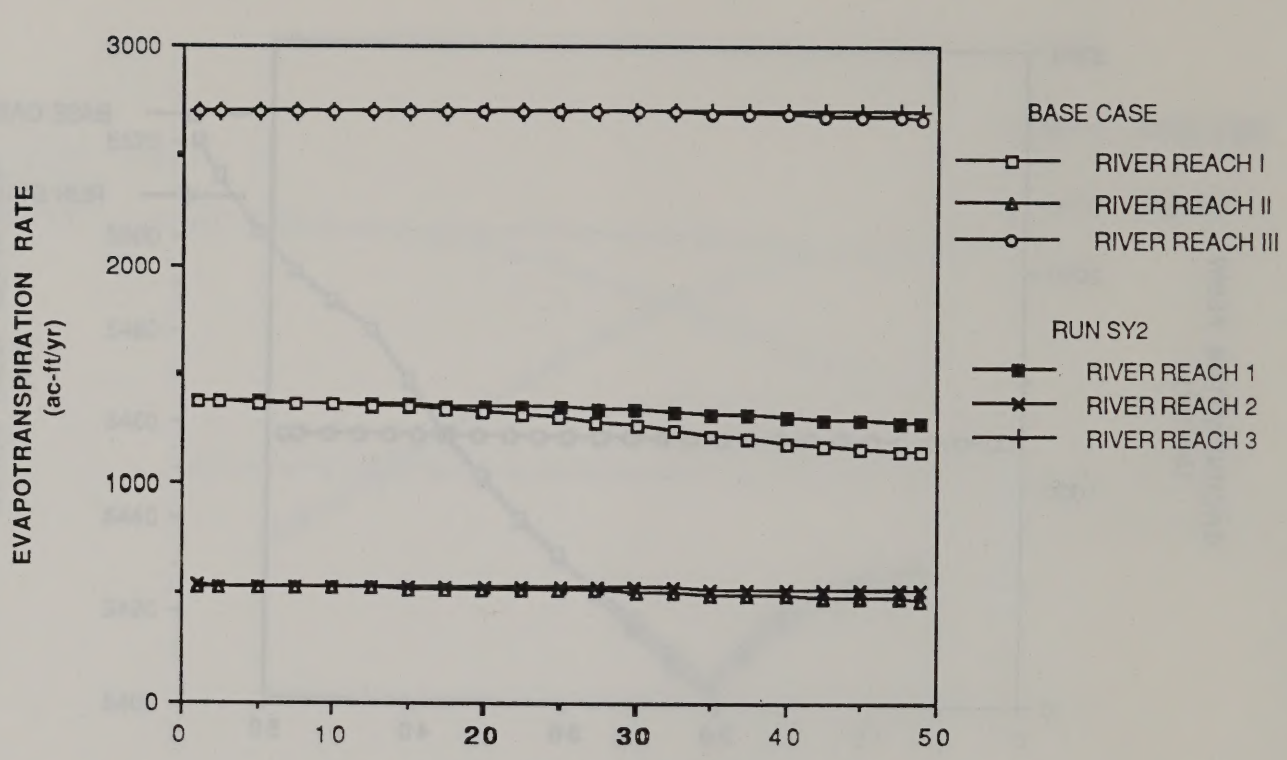


Figure C-3.22. Evapotranspiration for River Reaches I, II, III
BASE CASE vs. RUN SY2

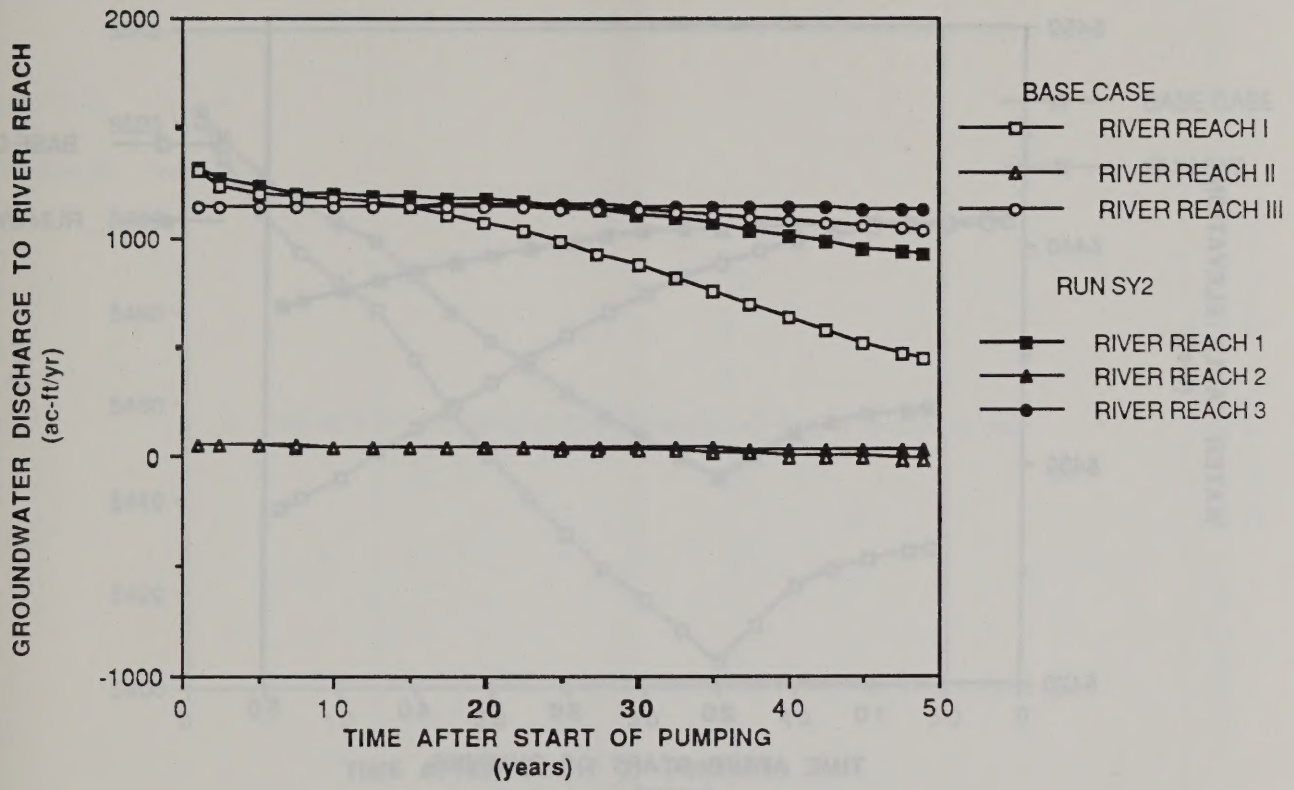


Figure C-3.23. Groundwater Discharge to River Reaches I, II, III
BASE CASE vs. RUN SY2

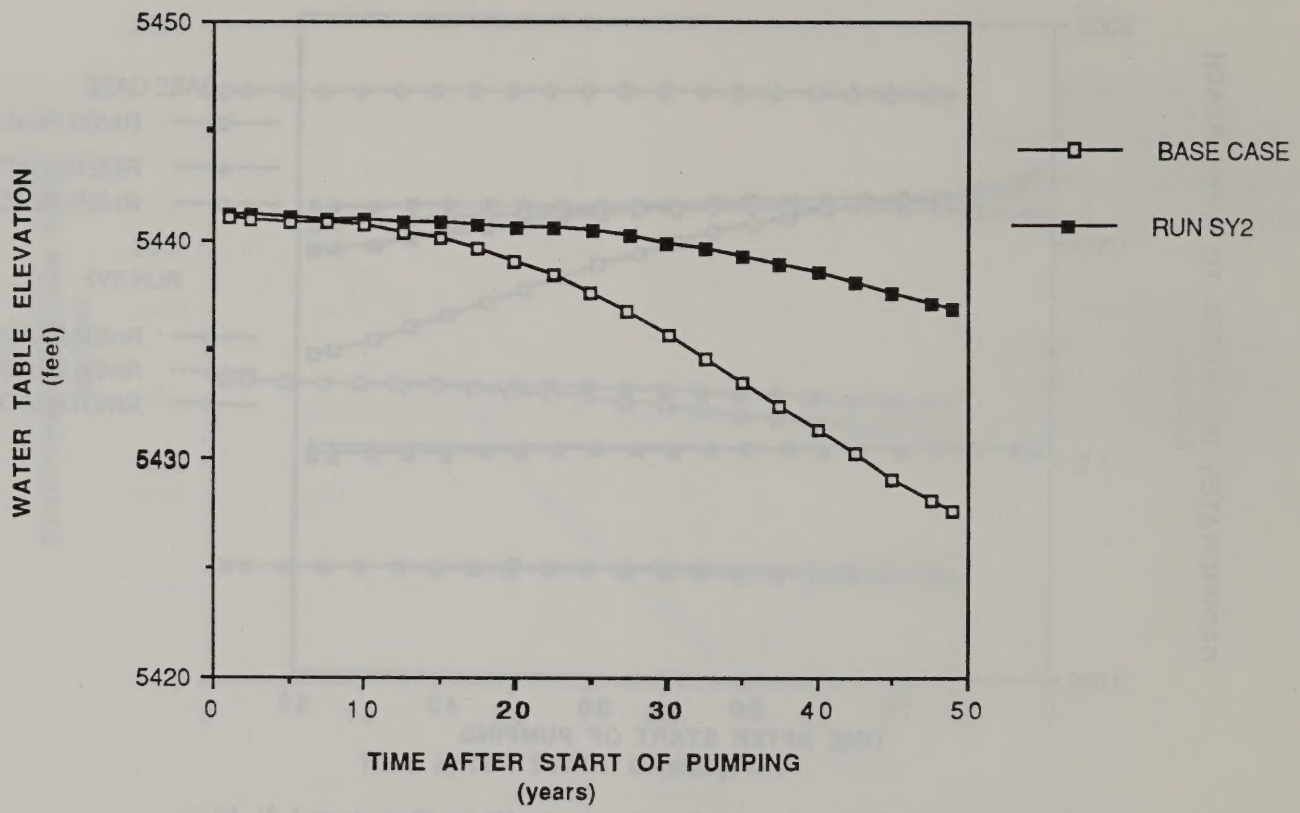


Figure C-3.24. Water Level vs. Time for MW-4
BASE CASE vs. RUN SY2

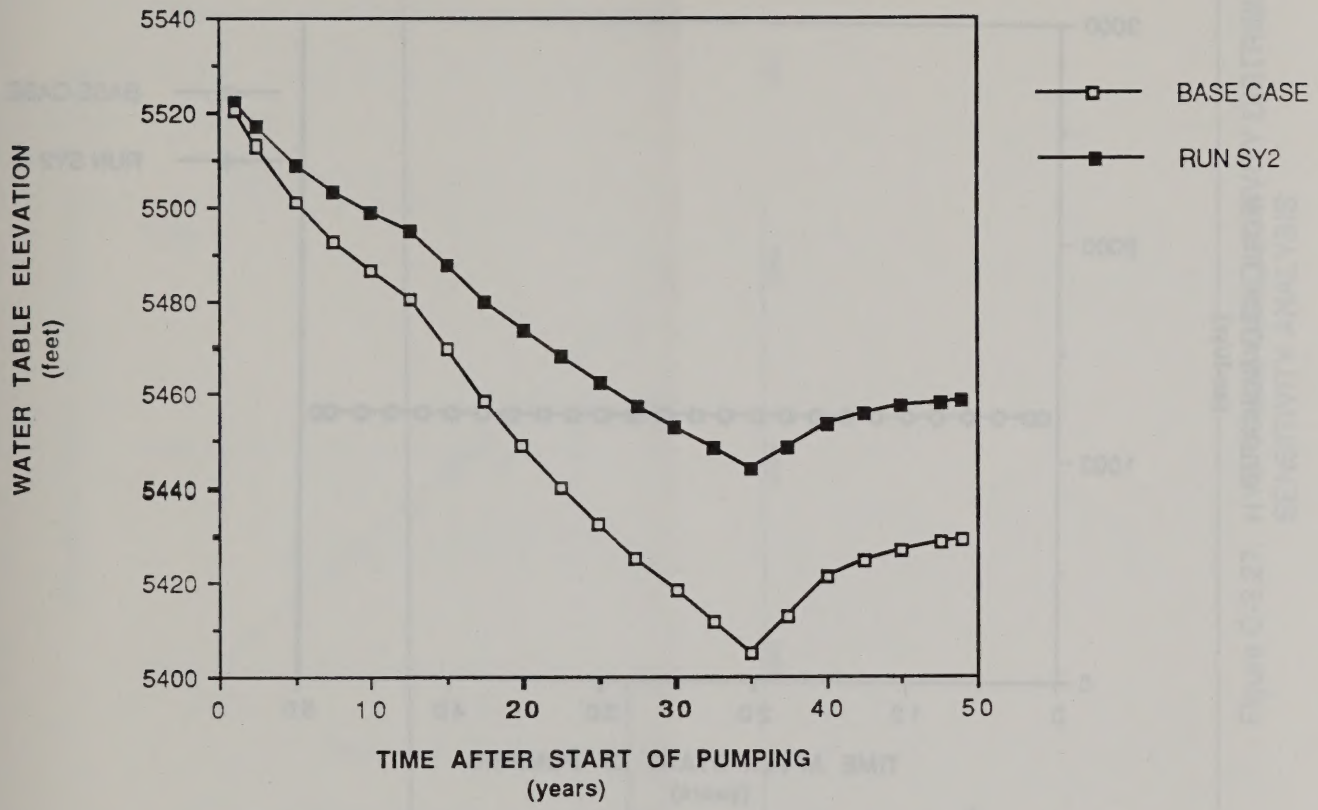


Figure C-3.25. Water Level vs. Time for TW-15
BASE CASE vs. RUN SY2

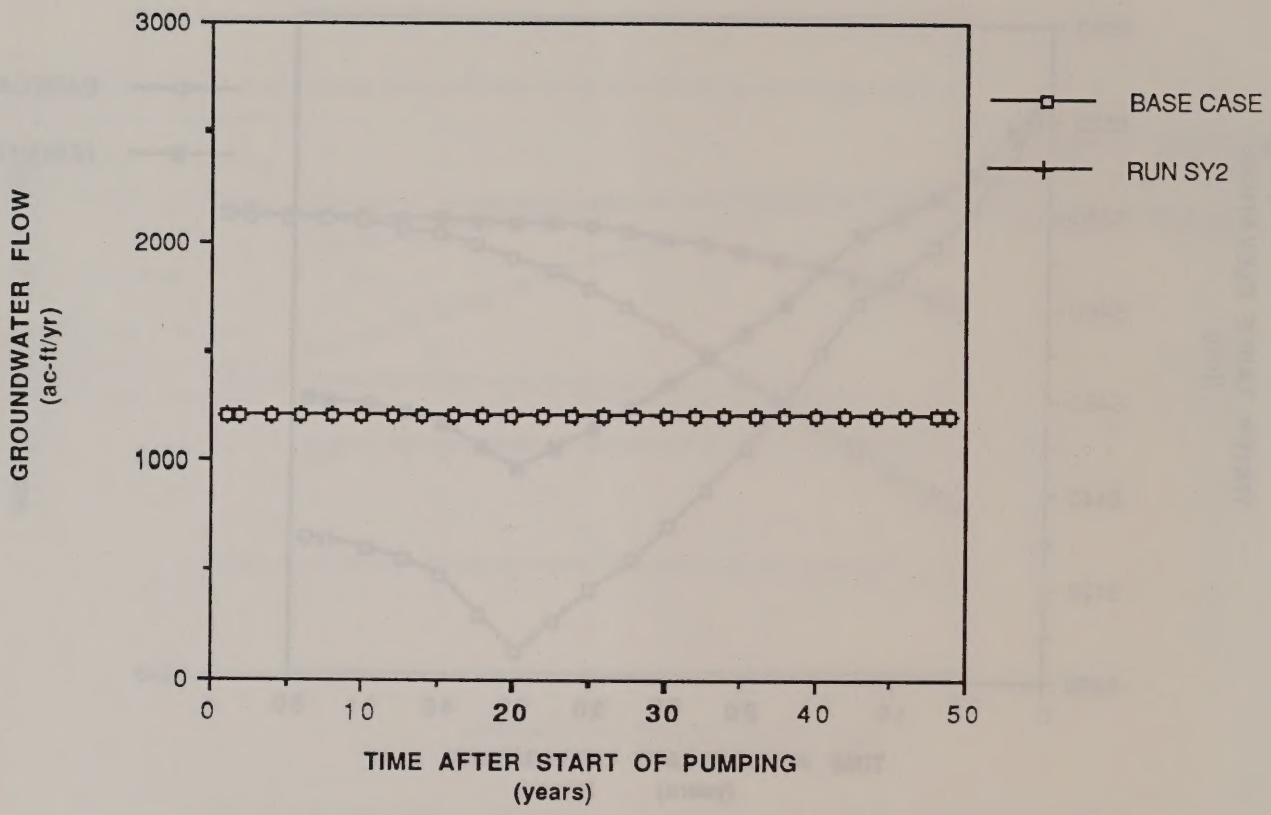


Figure C-3.26. Groundwater Flow from Model Area
BASE CASE vs. RUN SY2

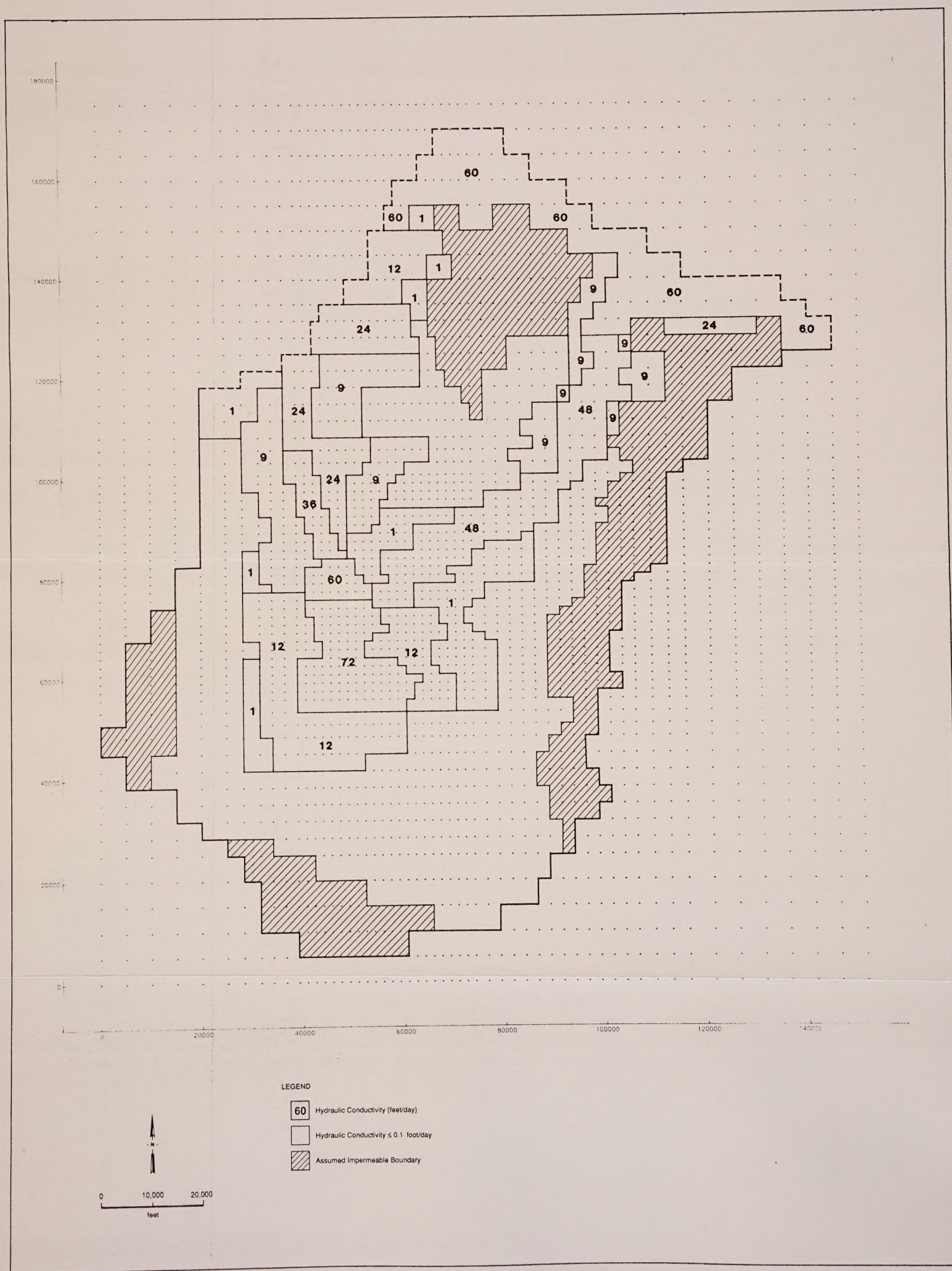
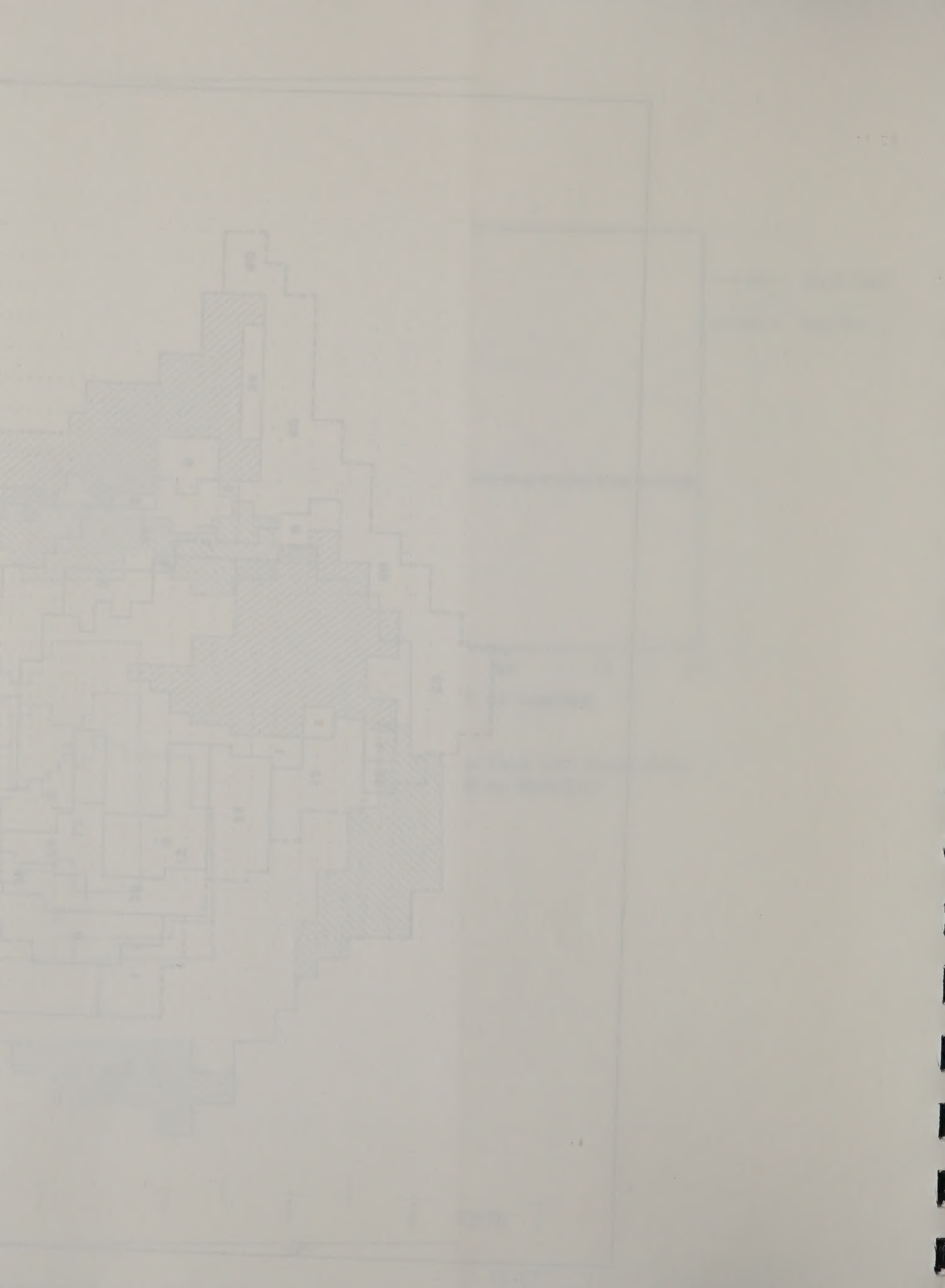


Figure C-3.27. HYDRAULIC CONDUCTIVITY DISTRIBUTION USED IN SENSITIVITY ANALYSIS



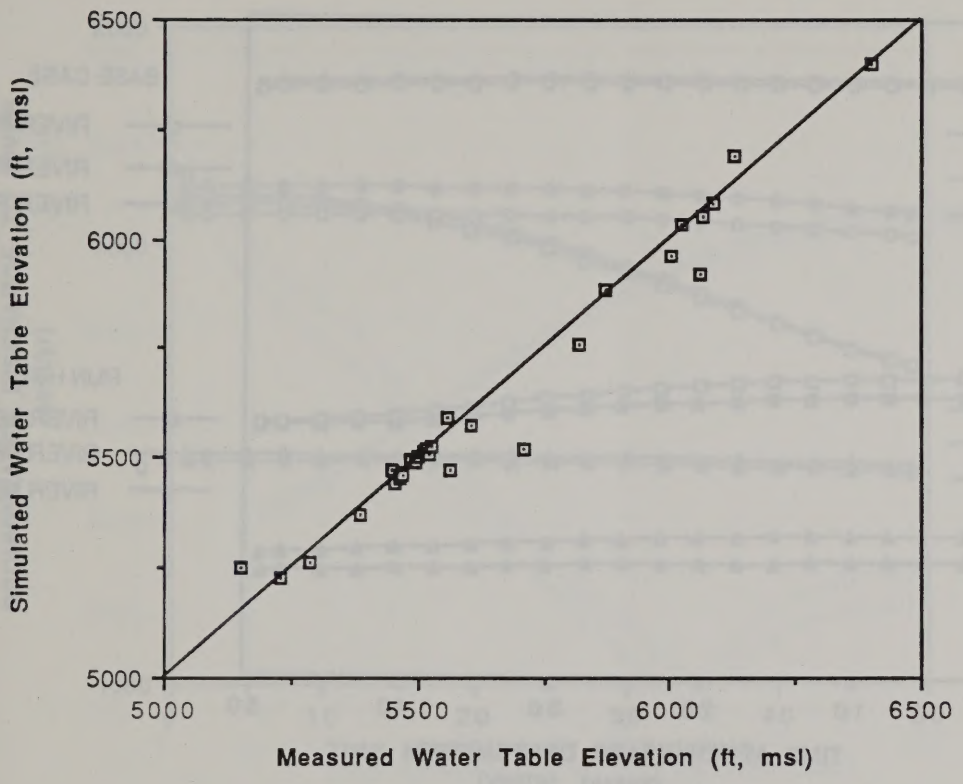


Figure C-3.28. Measured vs Simulated Water Table Elevation
(Smooth Hydraulic Conductivity)

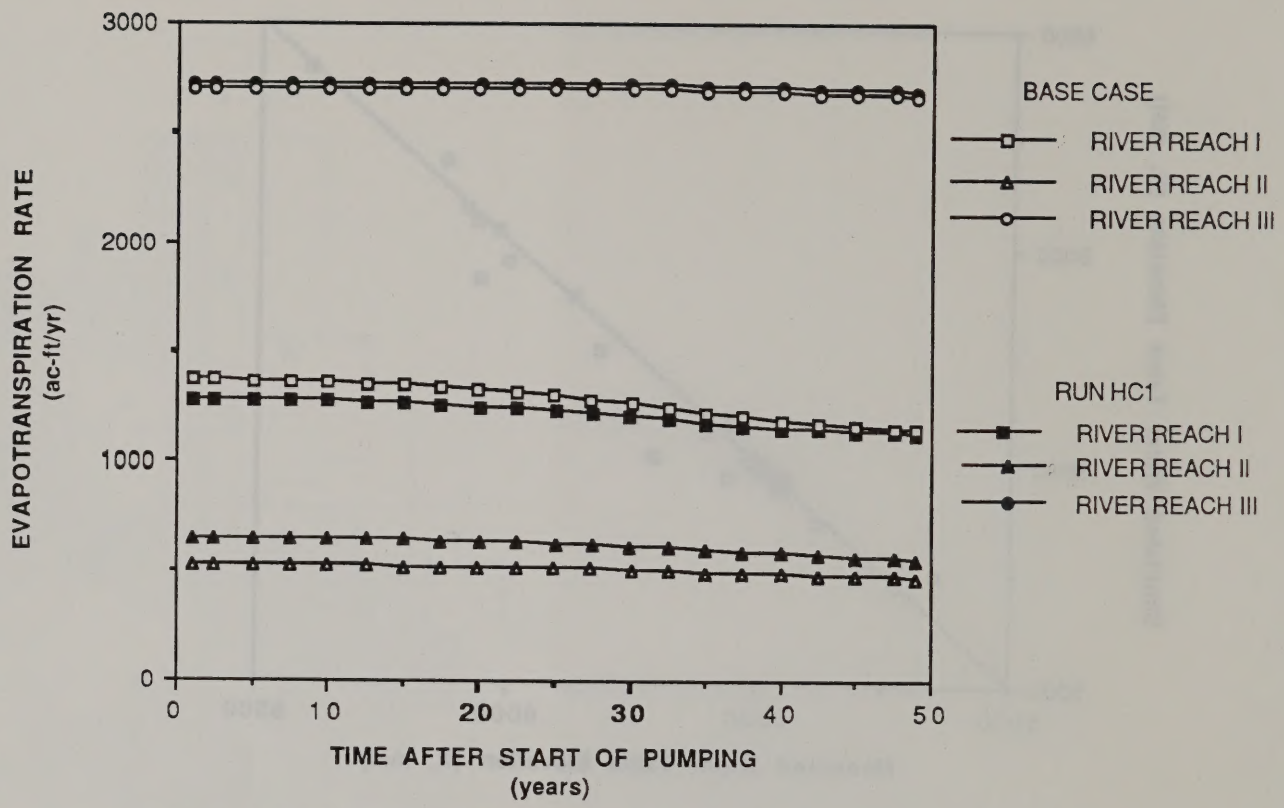


Figure C-3.29. Evapotranpiration for River Reaches I, II, III
BASE CASE vs. RUN HC1

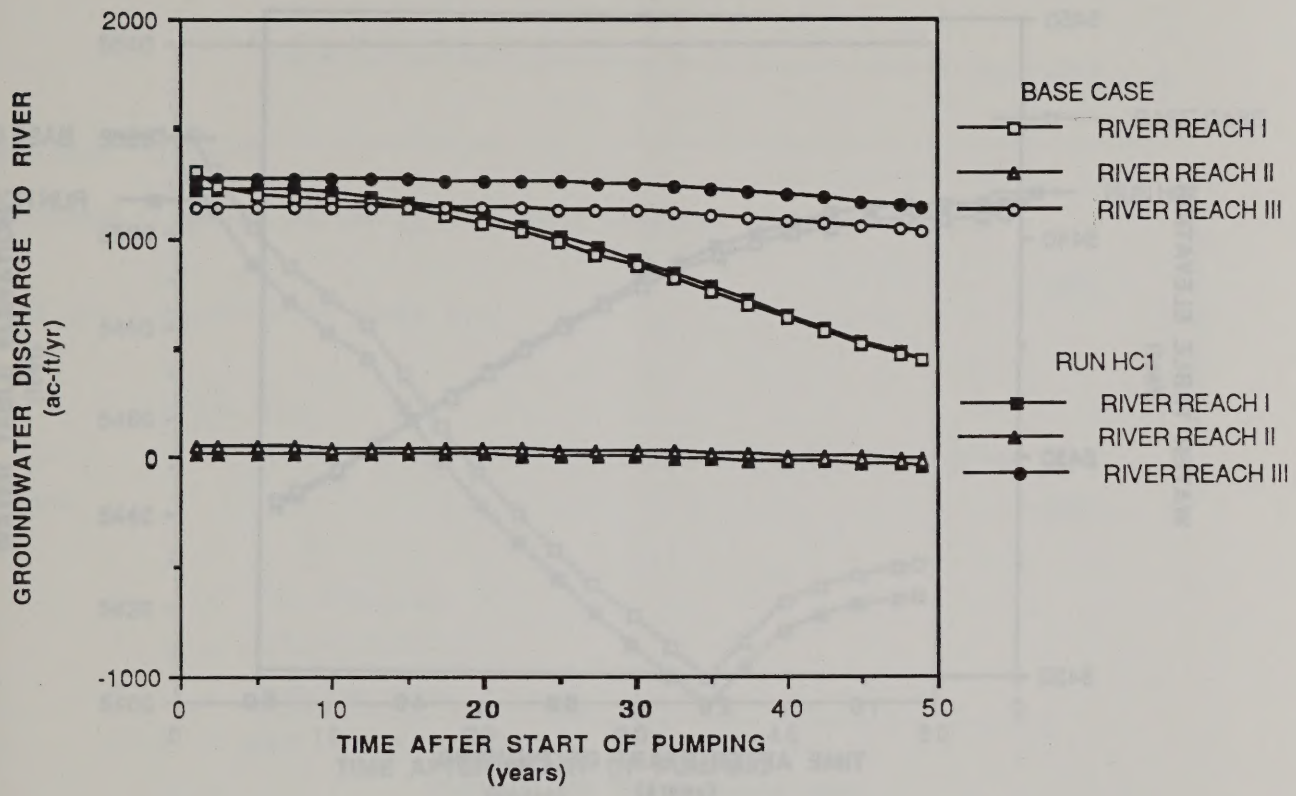


Figure C-3.30. Groundwater Discharge to River Reaches I, II, III
BASE CASE vs. RUN HC1

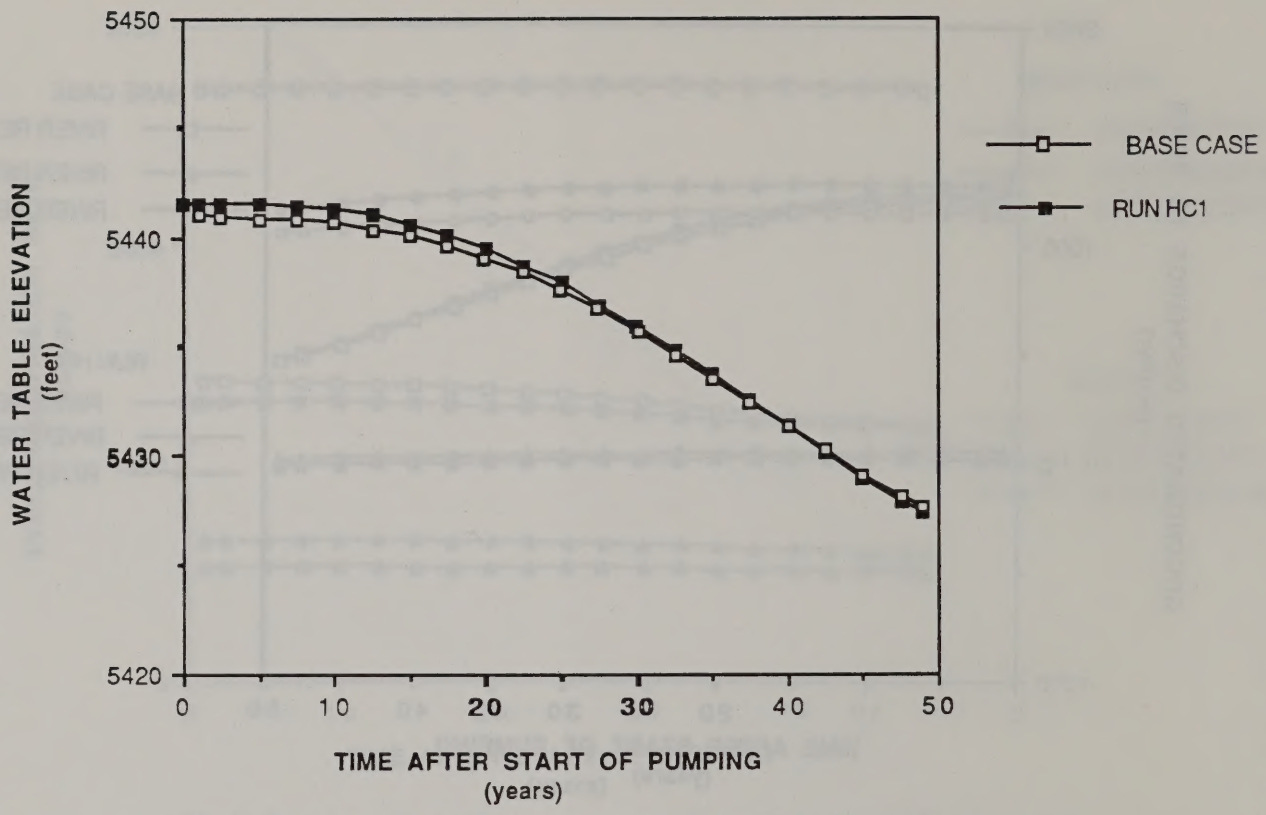


Figure C-3.31. Water Level vs. Time for MW-4
BASE CASE vs. RUN HC1

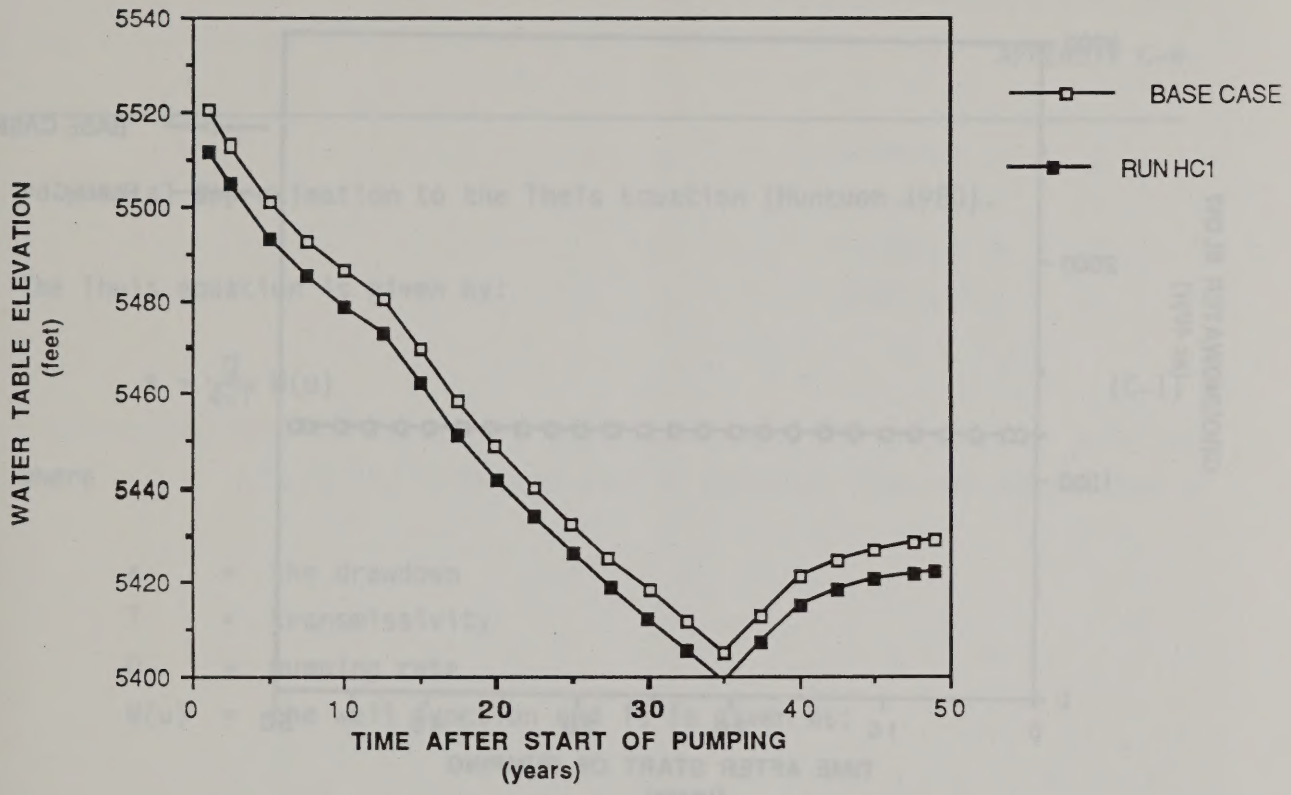


Figure C-3.32. Water Level vs. Time for TW-15
BASE CASE vs. RUN HC1

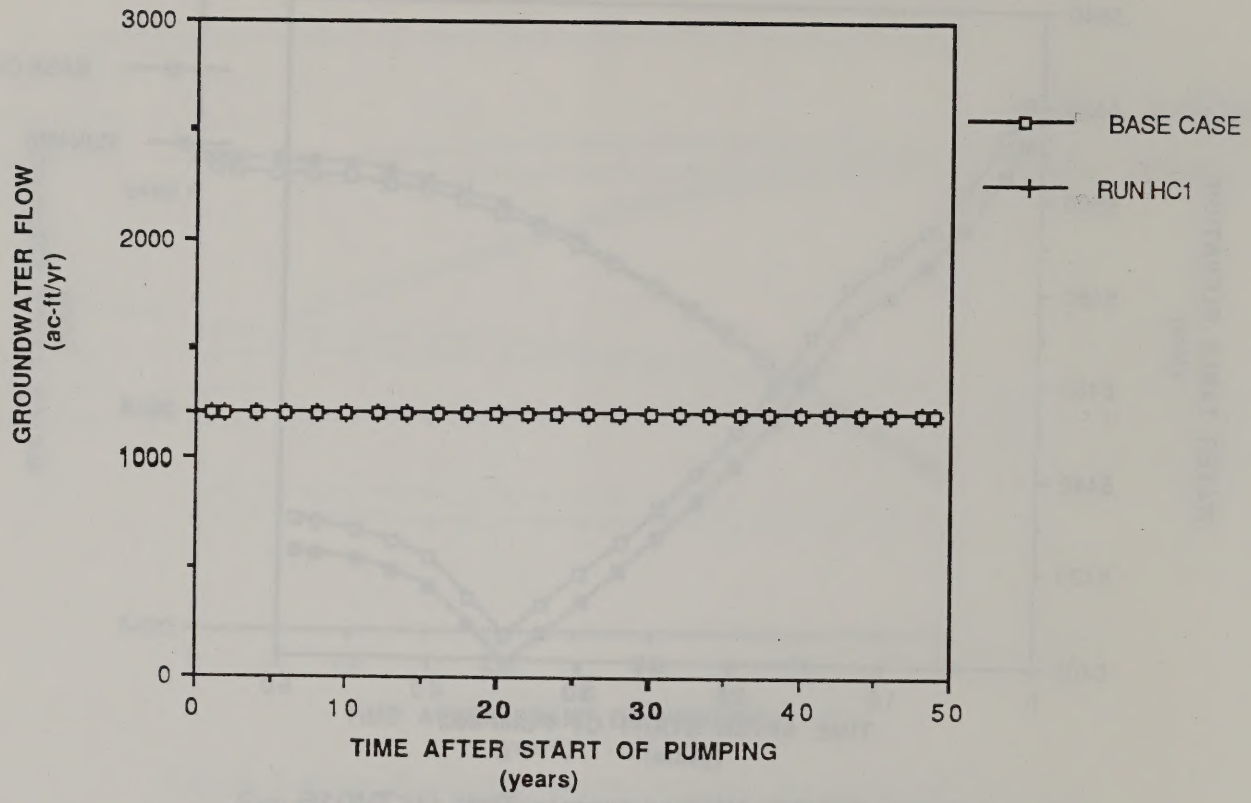


Figure C-3.33. Groundwater Flow from Model Area
BASE CASE vs. RUN HC1

APPENDIX C-4

Polynomial approximation to the Theis Equation (Huntoon 1980).

The Theis equation is given by:

$$s = \frac{Q}{4\pi T} W(u) \qquad \text{(C-1)}$$

where

s = the drawdown
T = transmissivity
Q = pumping rate
W(u) = the well function and it is given as:

$$W(u) = -.05772 - \text{Ln } u + u - \frac{u^2}{2.2!} + \frac{u^3}{3.3!} - + \ldots \qquad \text{(C-2)}$$

and

$$u = \frac{r^2 S}{4Tt} \qquad \text{(C-3)}$$

where

S = storage coefficient
r = radial distance from the pumped well
t = time of pumping

The well function is aproximated by the following polynomial:

$$W(u) = \frac{1}{ue^{u}} \cdot \frac{d_o + d_1 U + U^2}{f_o + f_1 u + u^2} \qquad \text{(C-4)}$$

where

$d_o = 0.250621$
$d_1 = 2.334733$
$f_o = 1.681534$
$f_1 = 3.330657$
$1 \leq u \leq \infty$

According to Huntoon, the error associated with using the above polynomial to approximate the well function is less than $\pm 5 \times 10^{-5}/(ue^{u})$.

APPENDIX D
BOREHOLE GEOPHYSICAL LOGS

STRATA DATA INC.

DUAL NORMAL ELECTRIC LOG WITH S.P. AND GAMMA RAY

FILE NO. 5111

COMPANY WOODWARD-CLYDE CONSULTANTS

WELL MW - 1

FIELD TOANA DRAW

COUNTY ELKO STATE NEVADA

LOCATION:

SE 1/4

SEC 35 TWP 42N RGE 65E

Other Services

SONIC/CAL.

TEMP. LOG

Elevations:

KB

DF

GL

Permanent Datum GROUND LEVEL Elev.

Log Measured from G.L. 0 Ft. Above Permanent Datum

Drilling Measured from G.L.

Date	08/11/88											
Run No.	ONE											
Depth—Driller	540											
Depth—Logger	550											
Bottom Logged Interval	542											
Top Logged Interval	2											
Casing—Driller	6 5/8 @		@				@					
Casing—Logger												
Bit Size	6"											
Type Fluid in Hole	MUD											
Density and Viscosity												
pH and Fluid Loss		cc		cc		cc		cc				
Source of Sample	PIT											
Rm @ Meas. Temp.	17.5 @ 73°F	@ °F		@ °F		@ °F		@ °F				
Rmf @ Meas. Temp.	@ °F	@ °F		@ °F		@ °F		@ °F				
Rmc @ Meas. Temp.	@ °F	@ °F		@ °F		@ °F		@ °F				
Source of Rmf and Rmc												
Rm @ BHT	@ °F	@ °F		@ °F		@ °F		@ °F				
Time Since Circ.												
Max. Rec. Temp. Deg. F.	78.8°F	°F		°F		°F		°F				
Equip. No. and Location	102 ELKO											
Recorded By	SPOHR											
Witnessed By	MR. MERRELL											

FOLD HERE

THIS HEADING AND LOG CONFORMS TO API RECOMMENDED STANDARD PRACTICE RP-31

Gamma Ray				Equipment Data				Density			
Run No.	ONE			Run No.							
Tool Model No.	GRS27A20			Tool Model No.							
Serial No.	118			Serial No.							
Diam.	1 3/4			Diam.							
Detect. Model No.	S4			Computer Model No.							
Type	SCINT.			Serial No.							
Length	4"			Source Model No.							
Dist. to Source	N/A			Serial No.							
General				Computer Data							
Hoist Truck No.	102										
Auxiliary Equipment											

Logging Data

General				Gamma Ray				Density			
Run No.	Depths From	Depths To	Speed Ft./Min.	T.C. Sec.	Sens. Settings	Zero Div. L or R	API G.R. Units Per Log Div.	T.C. Sec.	Density Scale	Correction Scale	Porosity Scale Data
1	2	550	20	3	235	2L					

Remarks:

Reference Literature:

SPONTANEOUS POTENTIAL Millivolts	DEPTH	RESISTIVITY Ohms m^2/m	

5

\- +

GAMMA RAY

RADIATION INTENSITY INCREASES

24 API UNITS 144

5" = 100'

16" NORMAL

0 50 100

64" NORMAL

0 50 100

0

100

GR

SP

16"

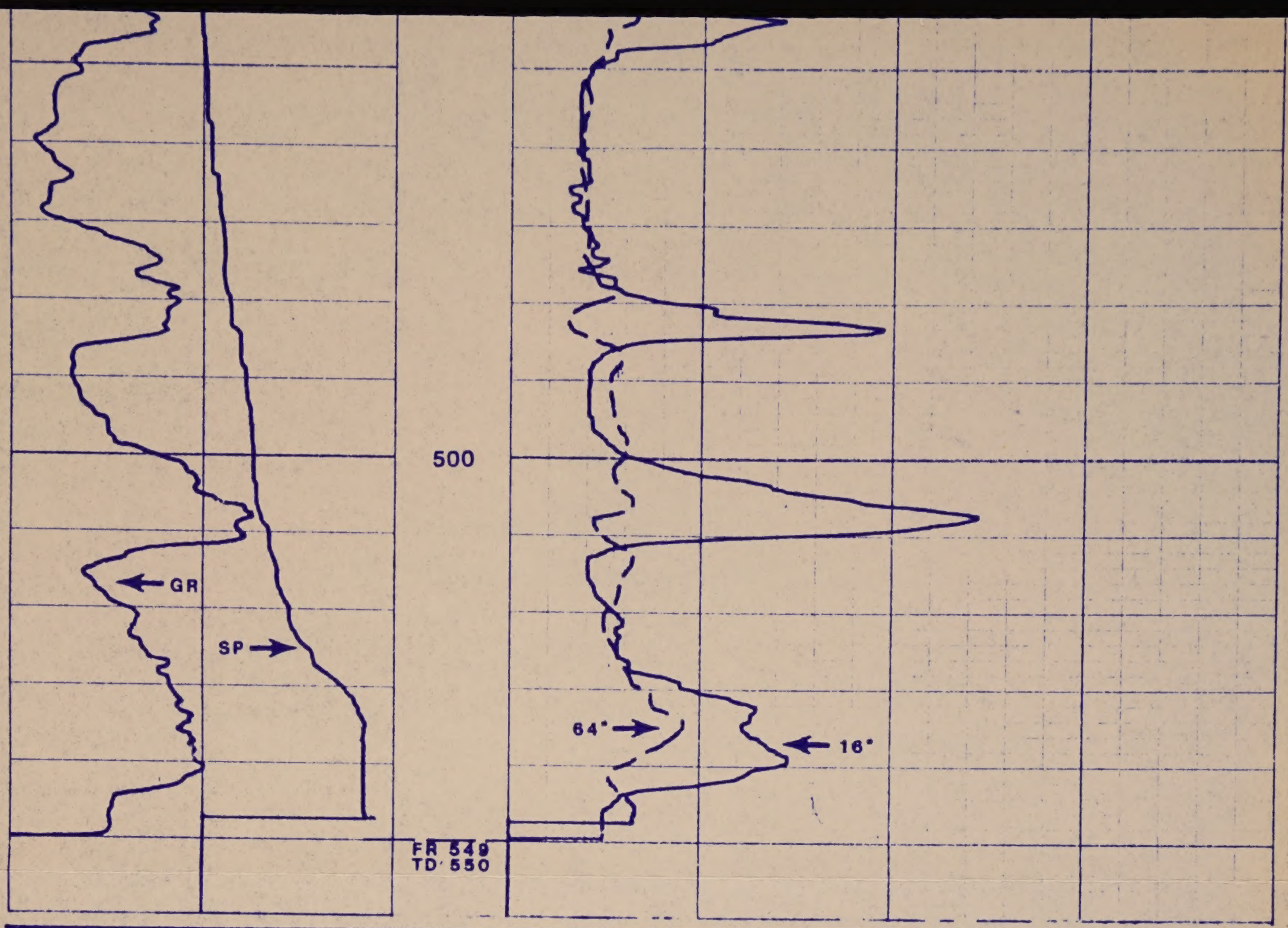
64"

100

200

300

400



24 API UNITS 144		0 64" NORMAL 50	
RADIATION INTENSITY INCREASES GAMMA RAY			
− 5 +		0 16" NORMAL 50	100
SPONTANEOUS POTENTIAL Millivolts	DEPTH	RESISTIVITY Ohms m²/m	

Company	WOODWARD–CLYDE CONSULTANTS		Drillers T.D.	540	
Well	MW – 1		Log F.R.	549	
Field	TOANA DRAW		Log T.D.	550	
County	ELKO		Elevations:		
State	NEVADA		K.B.	D.F.	G.L.

BLM Library
Denver Federal Center
Bldg. 50, OC-521
P.O. Box 25047
Denver, CO 80225

TD
195
.E4
E646
1989e
v.2

88076962

STRATA DATA INC

TEMPERATURE LOG

FILE NO 5111

COMPANY WOODWARD-CLYDE CONSULTANTS

WELL MW - 1

FIELD TOANA DRAW

COUNTY ELKO STATE NEVADA

LOCATION

SEC 35 TWP 42N RGE 65E

Other Services
DNEL/GR
SONIC/CAL.

Permanent Datum GROUND LEVEL Elev. 0 Ft. Above Permanent Datum

Log Measured from G.L.

Drilling Measured from G.L.

Elevations
KB
DF
GL

Date	08/11/88																						
Run No.	ONE																						
Depth—Driller	540																						
Depth—Logger	550																						
Bottom Logged Interval	550																						
Top Logged Interval	2																						
Casing—Driller	6 5/8 @ 18																						
Casing—Logger	18																						
Bit Size	6"																						
Type Fluid in Hole	MUD																						
Density and Viscosity																							
pH and Fluid Loss																							
Source of Sample																							
Rm @ Meas. Temp	@ F	@ F	@ F	@ F	@ F	@ F	@ F	@ F	@ F	@ F	@ F	@ F	@ F	@ F	@ F	@ F	@ F	@ F	@ F	@ F	@ F	@ F	@ F
Rmf @ Meas. Temp	@ F	@ F	@ F	@ F	@ F	@ F	@ F	@ F	@ F	@ F	@ F	@ F	@ F	@ F	@ F	@ F	@ F	@ F	@ F	@ F	@ F	@ F	@ F
Rmc @ Meas. Temp	@ F	@ F	@ F	@ F	@ F	@ F	@ F	@ F	@ F	@ F	@ F	@ F	@ F	@ F	@ F	@ F	@ F	@ F	@ F	@ F	@ F	@ F	@ F
Source Rmf / Rmc																							
Rm @ BHT	@ 79.8 F	@ F	@ F	@ F	@ F	@ F	@ F	@ F	@ F	@ F	@ F	@ F	@ F	@ F	@ F	@ F	@ F	@ F	@ F	@ F	@ F	@ F	@ F
Time Since Circ																							
Max Rec Temp Deg F																							
Equip No and Location	102 ELKO																						
Recorded By	SPOHR																						
Witnessed By	MR. MERRELL																						

FOLD HERE ↓

THIS HEADING AND LOG CONFORMS TO API RECOMMENDED STANDARD PRACTICE RP 1

REMARKS

Changes in Mud Type or Additional Samples

Date / Sample No.				
Depth-Driller				
Type Fluid in Hole				
Dens / Visc.				
pH / Fluid Loss		cc		cc
Source of Sample				
Rm @ Meas. Temp.	@ F		@ F	
Rmf @ Meas. Temp.	@ F		@ F	
Rmc @ Meas. Temp	@ F		@ F	
Source Rmf / Rmc				
Rm @ BHT	@ F		@ F	
Rmf @ BHT	@ F		@ F	
Rmc @ BHT	@ F		@ F	

Scale Changes

Type Log	Depth	Scale Up Hole	Scale Down Hole

Equipment Data

Run No.	Tool Type	Pad Type	Tool Position	Other
ONE	TEMP.		FREE	COMPROBE

	DEPTH	TEMPERATURE DEGREES F
		TEMPERATURE INCREASES →

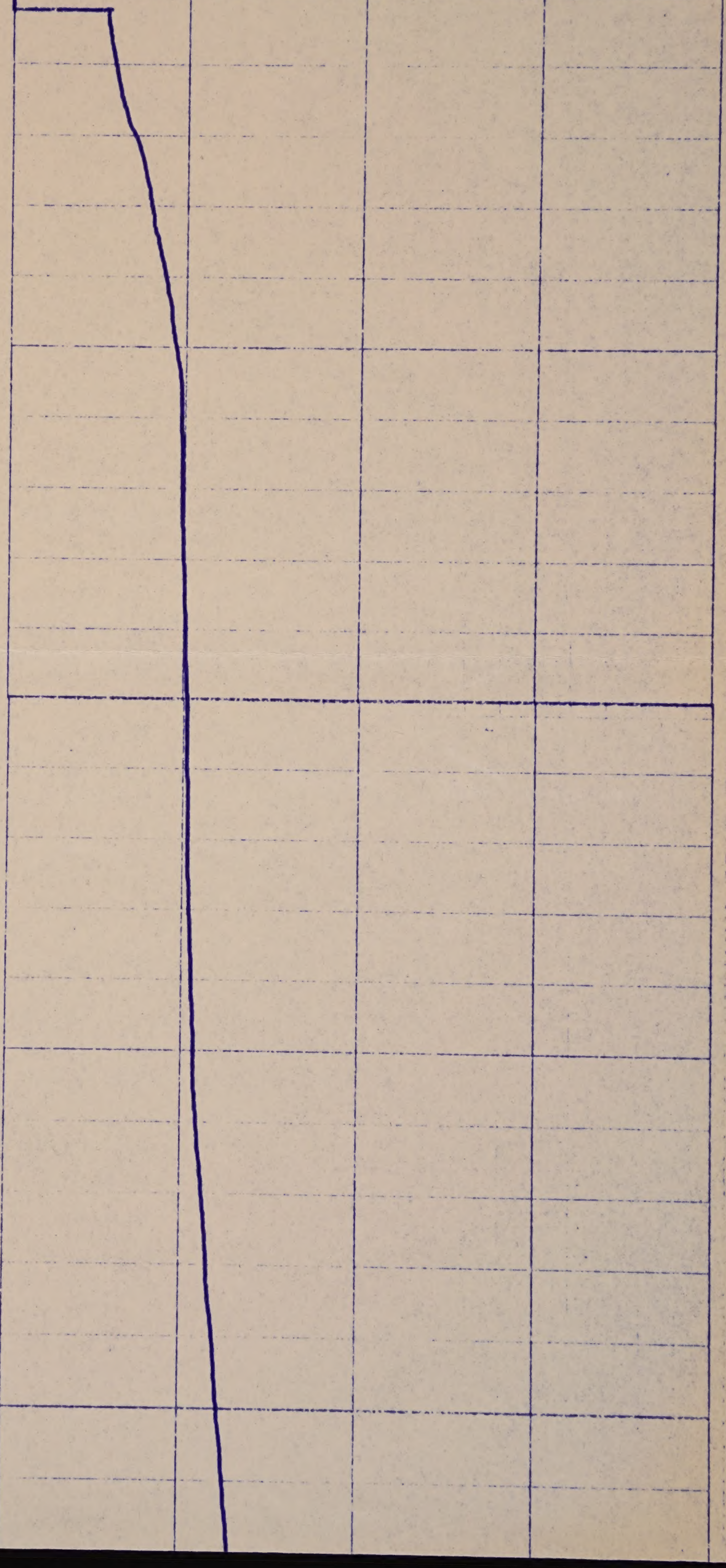
65 75 85

5" = 100'

0

100

200



300

400

500

FR 550
TD 550

65 75 85

TEMPERATURE INCREASES

DEPTH

TEMPERATURE
DEGREES F

Company	WOODWARD– CLYDE CONSULTANTS		Drillers T.D.	540	
Well	MW – 1		Log F.R.	550	
Field	TOANA DRAW		Log T.D.	550	
County	ELKO		Elevations:		
State	NEVADA		K.B.	D.F.	G.L. 8807962

BLM Library
Denver Federal Center
Bldg. 50, OC-521
P.O. Box 25047
Denver, CO 80225

TD
195
.E4
E646
1989e
v.2

STRATA DATA INC.

SONIC/CALIPER LOG

FILE NO. 5111

COMPANY WOODWARD CLYDE CONSULTANTS

WELL MW-1

FIELD TOANA DRAW

COUNTY ELKO STATE NEVADA

LOCATION:

SEC 35 TWP 42N RGE 65E

SE 1/4

Other Services
DNEL/GR
TEMP. LOG

Elevations:
KB
DF
GL

Permanent Datum GROUND LEVEL Elev. 0
Log Measured from G.L. Ft. Above Permanent Datum
Drilling Measured from G.L.

Date	08/11/88			
Run No.	ONE			
Depth—Driller	540			
Depth—Logger	550			
Bottom Logged Interval	544			
Top Logged Interval	4			
Casing—Driller	@	@	@	@
Casing—Logger				
Bit Size	8"			
Type Fluid in Hole	MUD			
Density and Viscosity				
pH and Fluid Loss		cc	cc	cc
Source of Sample				
Rm @ Meas. Temp.	@ °F	@ °F	@ °F	@ °F
Rmf @ Meas. Temp.	@ °F	@ °F	@ °F	@ °F
Rmc @ Meas. Temp.	@ °F	@ °F	@ °F	@ °F
Source of Rmf and Rmc				
Rm @ BHT	@ °F	@ °F	@ °F	@ °F
Time Since Circ.				
Max. Rec. Temp. Deg. F.	178.8°F			
Equip. No. and Location	102 ELKO			
Recorded By	SPOHR			
Witnessed By	MR. MERRELL			

FOLD HERE

THIS HEADING AND LOG CONFORMS TO API RECOMMENDED STANDARD PRACTICE RP-31

REMARKS

Changes in Mud Type or Additional Samples					
Date	Sample No.				
Depth-Driller					
Type Fluid in Hole					
Dens.	Visc.				
pH	Fluid Loss		cc		cc
Source of Sample					
Rm @ Meas. Temp.		@ °F		@ °F	
Rmf @ Meas. Temp.		@ °F		@ °F	
Rmc @ Meas. Temp.		@ °F		@ °F	
Source Rmf	Rmc				
Rm @ BHT		@ °F		@ °F	
Rmf @ BHT		@ °F		@ °F	
Rmc @ BHT		@ °F		@ °F	

Scale Changes			
Type Log	Depth	Scale Up Hole	Scale Down Hole

Equipment Data				
Run No.	Tool Type	Pad Type	Tool Position	Other

CALIPER	DEPTH	SONIC

HOLE SIZE - INCHES

3 13

MICROSECONDS

50 250

5" = 100'

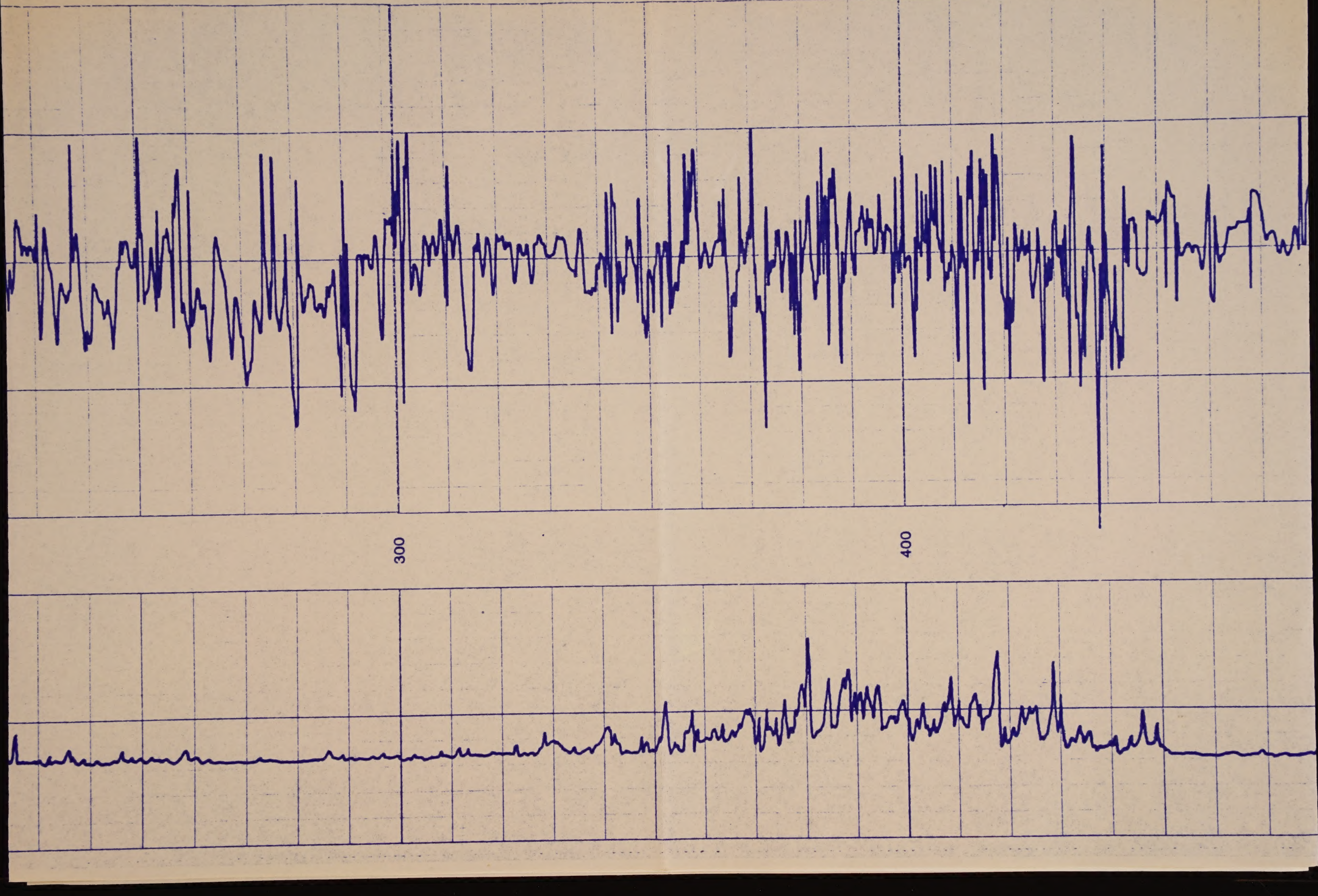
0

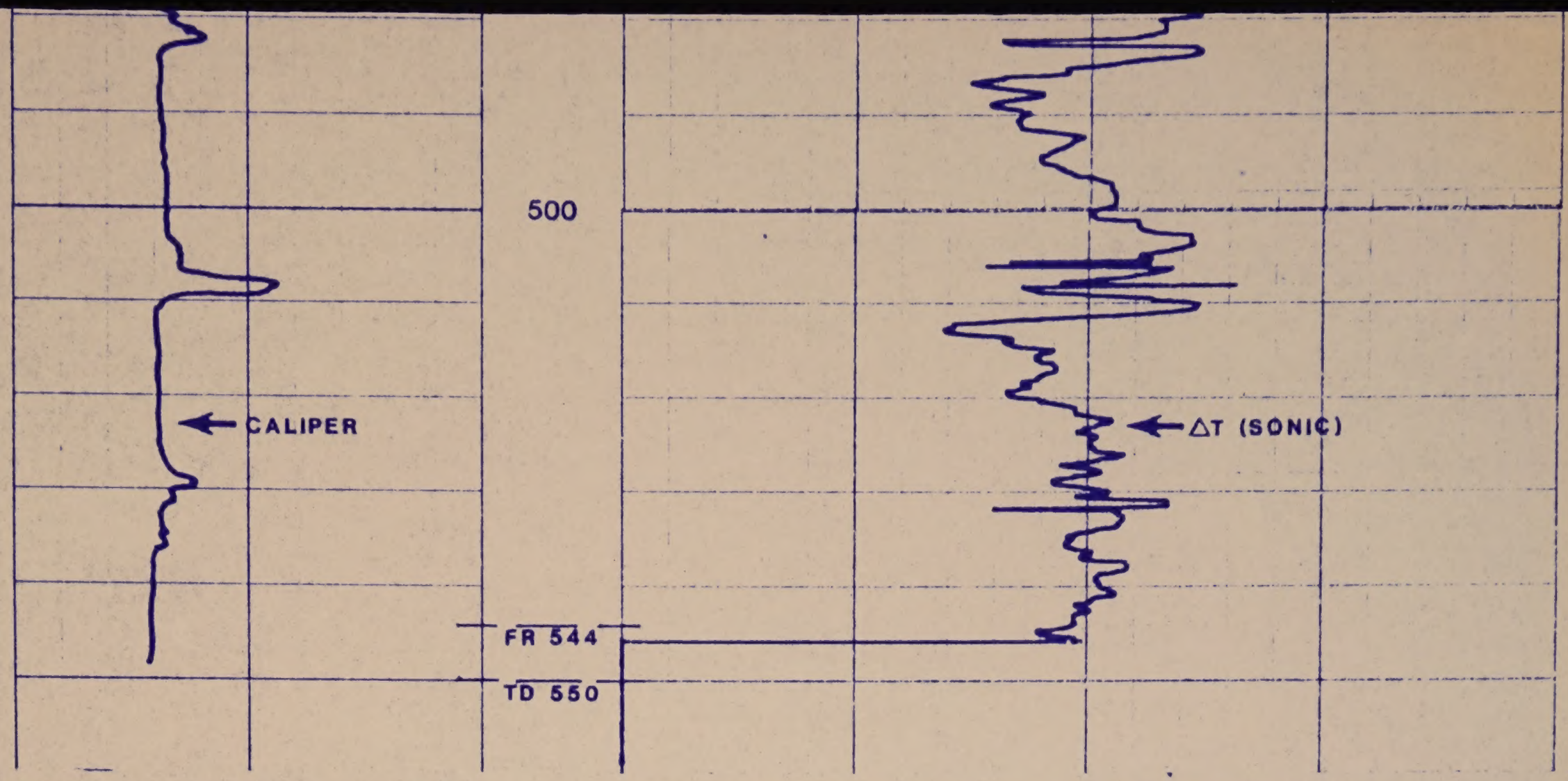
CALIPER

ΔT (SONIC)

100

200


300
400



3 13

HOLE SIZE - INCHES

50 250

MICROSECONDS

CALIPER	DEPTH	SONIC

Company	WOODWARD CLYDE CONSULTANTS		Drillers T.D.	540	
Well	MW - 1		Log F.R.	544	
Field	TOANA DRAW		Log T.D.	550	
County	ELKO		Elevations:		
State	NEVADA		K.B.	D.F.	G.L.

BLM Library
Denver Federal Center
Bldg. 50, OC-521
P.O. Box 25047
Denver, CO 80225

TD
195
.E4
E646
1989e
v.2

88076962

STRATA DATA INC.

DUAL NORMAL ELECTRIC LOG WITH S.P. AND GAMMA RAY

FILE NO. 5108

COMPANY WOODWARD-CLYDE CONSULTANTS

WELL MW-2

FIELD TOANA DRAW

COUNTY ELKO STATE NEVADA

LOCATION:

SEC ____ TWP ____ RGE ____

Other Services: 3-ARM CALIPER, TEMP. LOG, SONIC LOG

Permanent Datum GROUND LEVEL Elev. ____

Log Measured from G.L. 0 Ft. Above Permanent Datum

Drilling Measured from G.L.

Elevations: KB ____ DF ____ GL ____

Date	07/24/88			
Run No.	ONE			
Depth—Driller	607			
Depth—Logger	601			
Bottom Logged Interval	600			
Top Logged Interval	0			
Casing—Driller	7" @ 18	@	@	@
Casing—Logger	18			
Bit Size	5 3/4			
Type Fluid in Hole	FORMATION WATER			
Density and Viscosity				
pH and Fluid Loss	cc	cc	cc	cc
Source of Sample				
Rm @ Meas. Temp.	18.5 @ 72°F	@ °F	@ °F	@ °F
Rmf @ Meas. Temp.	@ °F	@ °F	@ °F	@ °F
Rmc @ Meas. Temp.	@ °F	@ °F	@ °F	@ °F
Source of Rmf and Rmc				
Rm @ BHT	16.2 @ 73.3°F	@ °F	@ °F	@ °F
Time Since Circ.	3 HRS.			
Max. Rec. Temp. Deg. F.	°F	°F	°F	°F
Equip. No. and Location	102 ELKO			
Recorded By	MC DONALD			
Witnessed By	MR. MERRELL			

FOLD HERE ↓

THIS HEADING AND LOG CONFORMS TO API RECOMMENDED STANDARD PRACTICE RP 31

Gamma Ray — Equipment Data — Density

Gamma Ray				Density			
Run No.	ONE			Run No.			
Tool Model No.	GRS27A20			Tool Model No.			
Serial No.	118			Serial No.			
Diam.	1 3/4			Diam.			
Detect. Model No.				Computer Model No.			
Type				Serial No.			
Length				Source Model No.			
Dist. to Source				Serial No.			

General				Computer Data			
Hoist Truck No.	102						
Auxiliary Equipment							

Logging Data

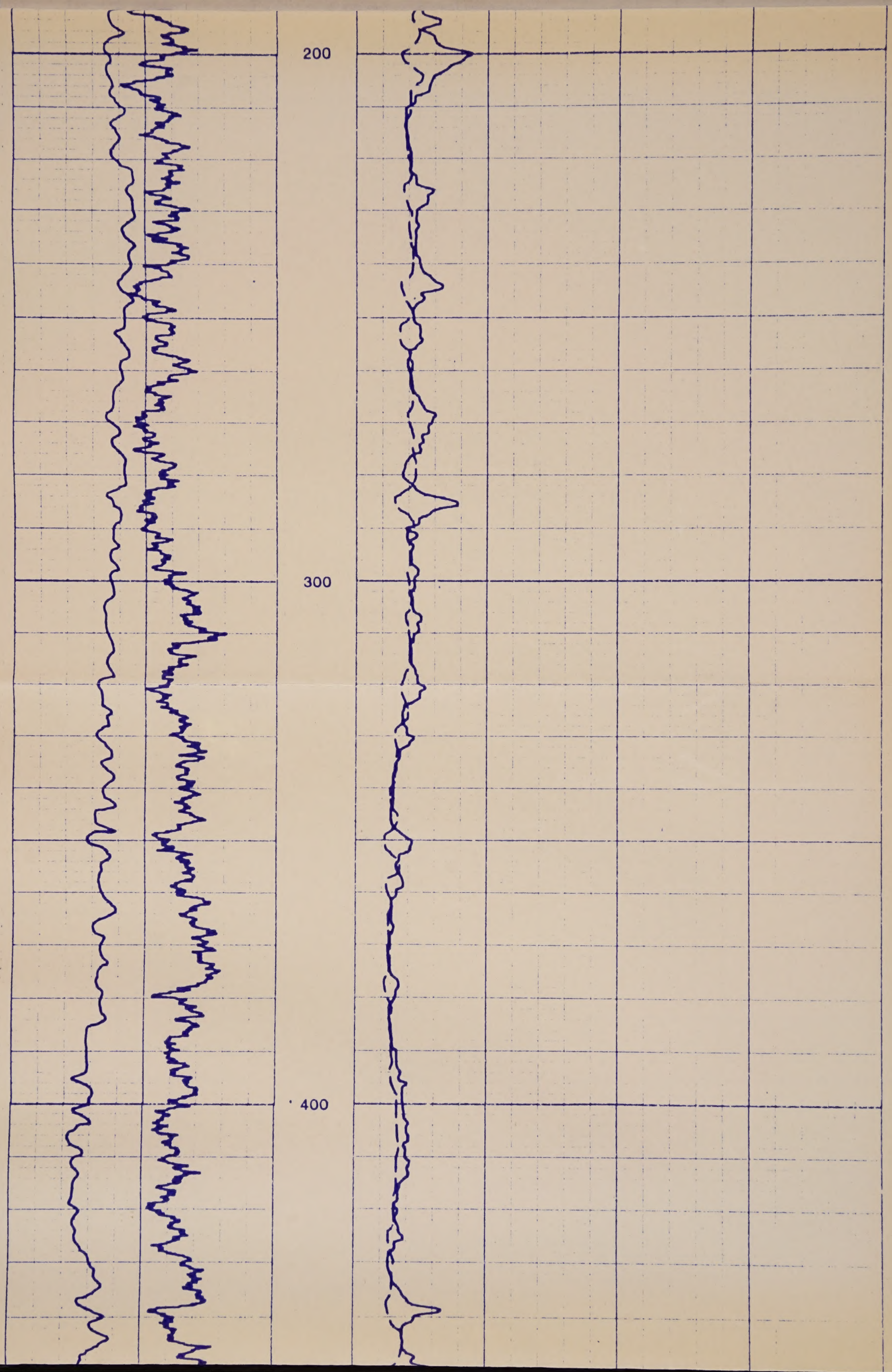
General				Gamma Ray					Density			
Run No.	Depths From	Depths To	Speed Ft./Min.	T.C. Sec.	Sens. Settings	Zero Div. L or R	API G.R. Units Per Log Div.		T.C. Sec.	Density Scale	Correction Scale	Porosity Scale Data
1	283	4	20	3	200	2L						

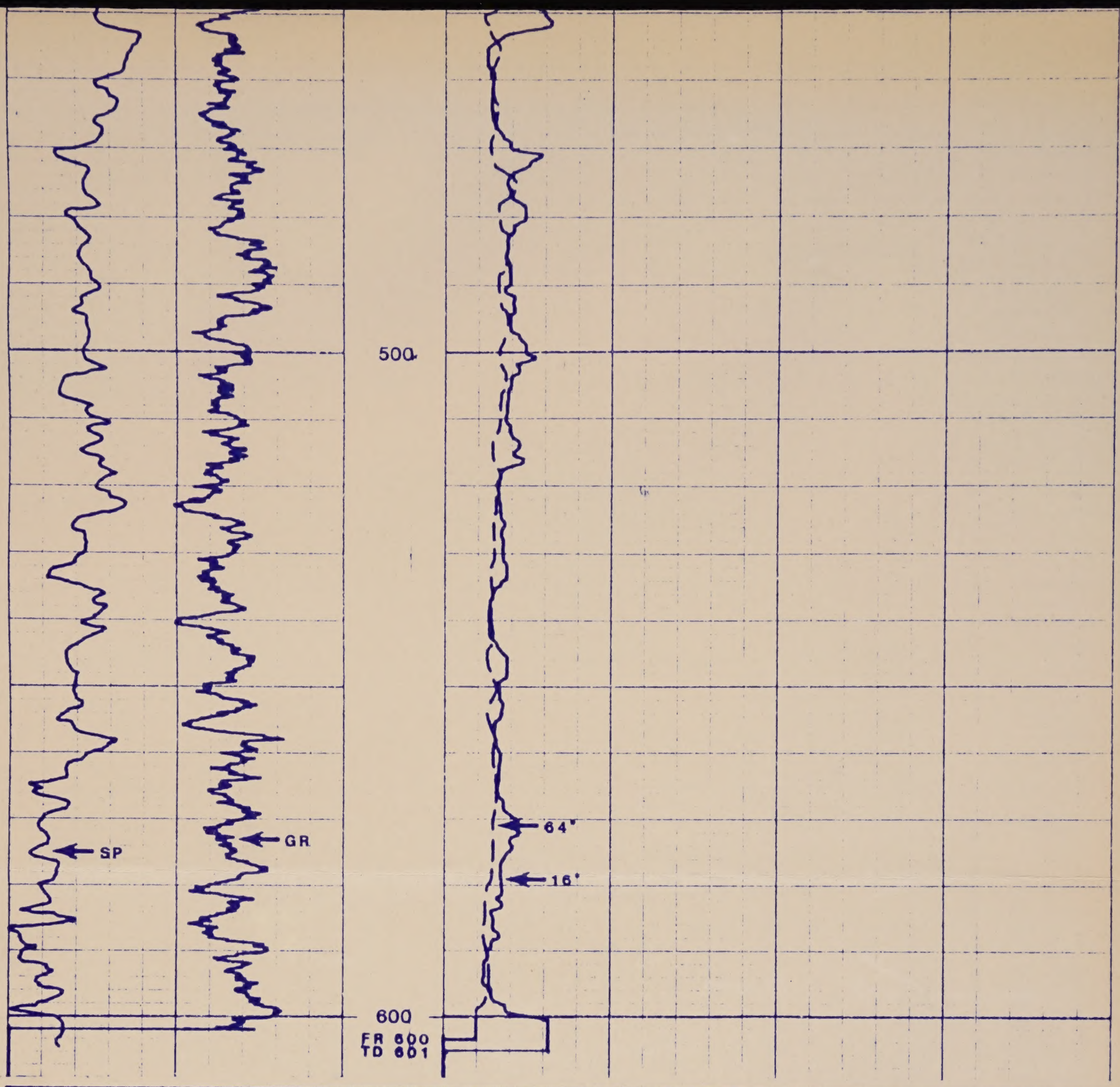
Remarks:

Reference Literature:

SPONTANEOUS POTENTIAL	DEPTH	RESISTIVITY	

Millivolts	DEPTH	Ohms m^2/m	
2 − ⟷ +		16" NORMAL 0 — 50	100
GAMMA RAY RADIATION INTENSITY INCREASES →		64" NORMAL 0 — 50	100
24 API UNITS 148	5" = 100'		


200
300
400



24 API UNITS 148		0 64" NORMAL 50 100
RADIATION INTENSITY INCREASES GAMMA RAY		
− ⟷ + (2)		0 16" NORMAL 50 100
SPONTANEOUS POTENTIAL Millivolts	DEPTH	RESISTIVITY Ohms m^2/m

Company	WOODWARD–CLYDE CONSULTANTS	Drillers T.D.	607
Well	MW – 2	Log F.R.	600
Field	TOANA DRAW	Log T.D.	601
County	ELKO	Elevations:	
State	NEVADA	K.B. D.F.	G.L.

BLM Library
Denver Federal Center
Bldg. 50, OC-521
P.O. Box 25047
Denver, CO 80225

TD
195
.E4
E646
1989e
V.2

88076962

STRATA DATA INC

TEMPERATURE LOG

FILE NO 5108

COMPANY WOODWARD CLYDE CONSULTANTS

WELL MW - 2

FIELD TOANA DRAW

COUNTY ELKO STATE NEVADA

LOCATION:

SEC _____ TWP _____ RGE _____

Other Services
GR/SP/DNEL
3-ARM CALIPER
SONIC

Permanent Datum GROUND LEVEL Elev _____
Lag Measured from G.L. 0 Ft. Above Permanent Datum
Drilling Measured from G.L.

Elevations
KB _____
DF _____
GL _____

Date	07/24/88							
Run No	ONE							
Depth—Driller	607							
Depth—Logger	601							
Bottom Logged Interval	601							
Top Logged Interval	85							
Casing—Driller	7" @ 16		@		@		@	
Casing—Logger	N/A							
Bit Size	5 3/4							
Type Fluid in Hole	FORMATION WATER							
Density and Viscosity								
pH and Fluid Loss		cc		cc		cc		cc
Source of Sample								
Rm @ Meas Temp		@ F		@ F		@ F		@ F
Rmf @ Meas Temp		@ F		@ F		@ F		@ F
Rmc @ Meas. Temp		@ F		@ F		@ F		@ F
Source of Rmf and Rmc								
Rm @ BHT		@ F		@ F		@ F		@ F
Time Since Circ								
Max Rec Temp Deg F	73.3 F			F		F		F
Equip No and Location	102 ELKO							
Recorded By	MC DONALD							
Witnessed By	MR. MERRELL							

THIS HEADING AND LOG CONFORMS TO API RP 33

FIELD PRINT

REMARKS

Scale Changes
Scale Up Hole
Scale Down Hole
Depth
Type Log

Equipment Data
Tool Type: TEMP.
Pad Type: NA
Tool Position: FREE
Other: COMPROBE

Changes in Mud Type or Additional Samples
Date | Sample No
Depth Driller
Type Fluid in Hole
Dens | Visc
pH | Fluid Loss
Source of Sample
Rm @ Meas Temp
Rmf @ Meas Temp
Rmc @ Meas Temp
Source Rmf | Rmc
Rm @ BHT
Rmf @ BHT
Rmc @ BHT

Run No							
ONE							
	@ F	@ F	@ F	@ F	@ F	@ F	@ F
	@ F	@ F	@ F	@ F	@ F	@ F	@ F
	@ F	@ F	@ F	@ F	@ F	@ F	@ F
	@ F	@ F	@ F	@ F	@ F	@ F	@ F
	@ F	@ F	@ F	@ F	@ F	@ F	@ F
	@ F	@ F	@ F	@ F	@ F	@ F	@ F

TEMPERATURE
DEGREES F

TEMPERATURE INCREASES

DEPTH

65
75
85
5" = 100'
100
200
300
TOOL STOPPED
TOOL STOPPED

TOOL STOPPED
400
500

600

FR 601
TD 601

65 75 85

TEMPERATURE INCREASES

DEPTH

TEMPERATURE
DEGREES F

Company	WOODWARD CLYDE CONSULTANTS	Drillers T.D.	607
Well	MW - 2	Log F.R.	601
Field	TOANA DRAW	Log T.D.	601
County	ELKO	Elevations:	
State	NEVADA	K.B.	D.F. G.L.

BLM Library
Denver Federal Center
Bldg. 50, OC-521
P.O. Box 25047
Denver, CO 80225

TD
195
.E4
E646
1989e
v.2

88076962

STRATA DATA INC

SONIC/CALIPER LOG

FILE NO. 5108

COMPANY WOODWARD-CLYDE CONSULTANTS

WELL MW - 2

FIELD TOANA DRAW

COUNTY ELKO STATE NEVADA

LOCATION:

SEC ____ TWP ____ RGE ____

Other Services
GR/SP/DNEL
3-ARM CALIPER
TEMP.

Permanent Datum GROUND LEVEL Elev. ____
Log Measured from G.L. 0 Ft. Above Permanent Datum
Drilling Measured from G.L.

Elevations:
KB ____
DF ____
GL ____

Date	07/24/88			
Run No.	ONE			
Depth—Driller	607			
Depth—Logger	601			
Bottom Logged Interval	598			
Top Logged Interval	0			
Casing—Driller	7" @ 16	@	@	@
Casing—Logger	16			
Bit Size	5 3/4			
Type Fluid in Hole	FORMATION WATER			
Density and Viscosity				
pH and Fluid Loss	cc	cc	cc	cc
Source of Sample				
Rm @ Meas. Temp.	@ °F	@ °F	@ °F	@ °F
Rmf @ Meas. Temp.	@ °F	@ °F	@ °F	@ °F
Rmc @ Meas. Temp.	@ °F	@ °F	@ °F	@ °F
Source of Rmf and Rmc				
Rm @ BHT	@ °F	@ °F	@ °F	@ °F
Time Since Circ.				
Max. Rec. Temp. Deg. F.	73.3 °F	°F	°F	°F
Equip. No. and Location	102 ELKO			
Recorded By	MC DONALD			
Witnessed By	MR. MERRELL			

THIS HEADING AND LOG CONFORMS TO API RECOMMENDED STANDARD PRACTICE RP-31

FOLD HERE

REMARKS

Scale Changes
Scale Down Hole
Scale Up Hole
Depth
Type Log

Equipment Data
Other
Tool Position
Pad Type
Tool Type

Changes in Mud Type or Additional Samples
Date | Sample No.
Depth-Driller
Type Fluid in Hole
Dens. | Visc.
pH | Fluid Loss
Source of Sample
Rm @ Meas. Temp.
Rmf @ Meas. Temp.
Rmc @ Meas. Temp.
Source Rmf | Rmc
Rm @ BHT
Rmf @ BHT
Rmc @ BHT
Run No.

CALIPER

HOLE DIAMETER
INCHES
13 23

DEPTH
3

SONIC

5" = 100'

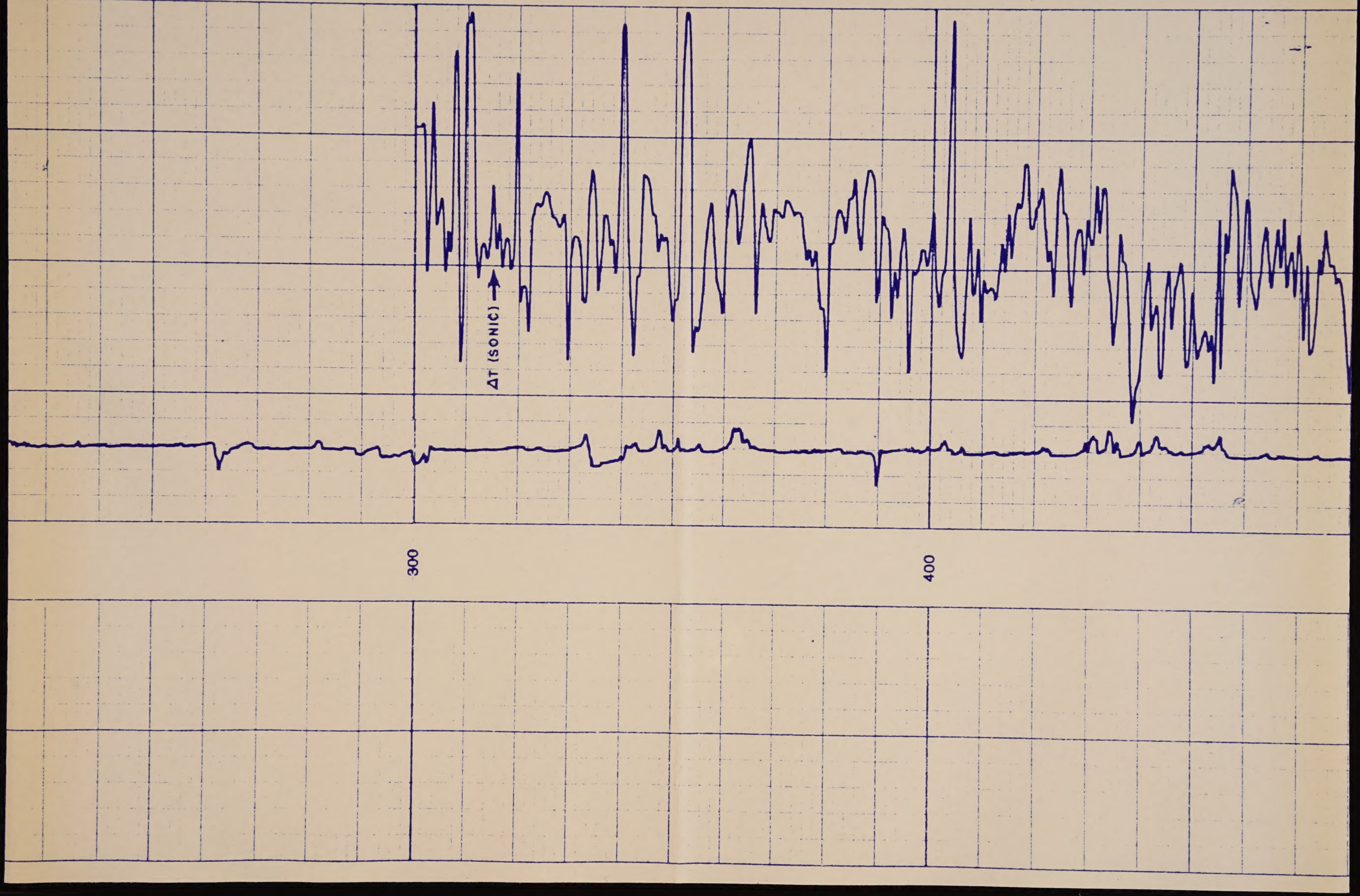
100 MICROSECONDS 200

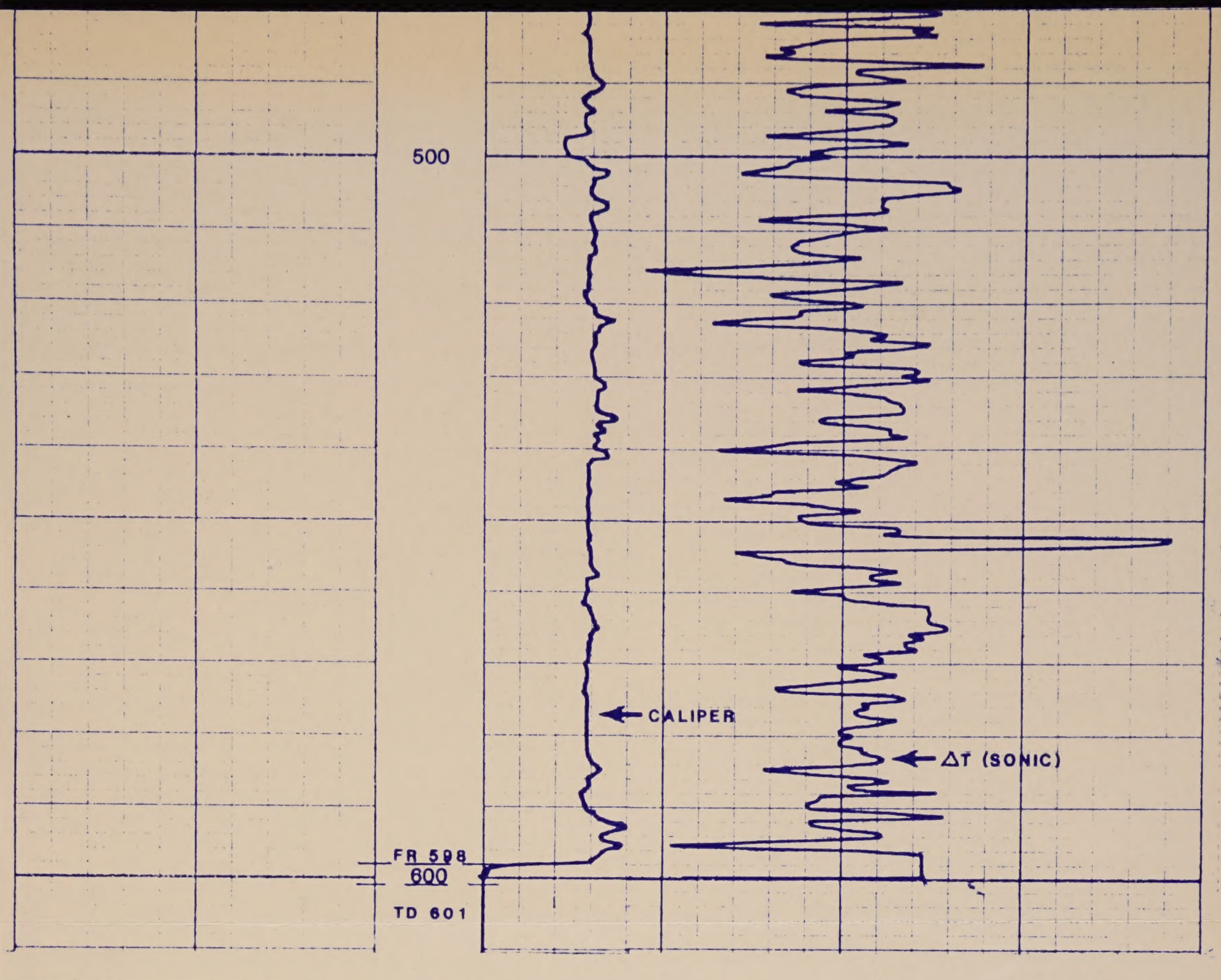
0

CALIPER

100

200


ΔT (SONIC)
300
400



100 MICROSECONDS 200

SONIC

3 | 13 23

HOLE DIAMETER
INCHES

DEPTH

CALIPER

Company **WOODWARD–CLYDE CONSULTANTS**

Well **MW – 2**

Field **TOANA DRAW**

County **ELKO**

State **NEVADA**

Drillers T D **607**

Log F R **598**

Log T D **601**

Elevations

K B D F G L

BLM Library
Denver Federal Center
Bldg. 50, OC-521
P.O. Box 25047
Denver, CO 80225

TD
195
.E4
E646
1989e
v.2

88076962

STRATA DATA INC.

DUAL NORMAL ELECTRIC LOG
WITH S.P. AND GAMMA RAY

FILE NO 5102

COMPANY WOODWARD-CLYDE CONSULTANTS
WELL MW-3
FIELD TOANA DRAW
COUNTY ELKO STATE NEVADA
LOCATION:
SEC ____ TWP ____ RGE ____

Other Services
GR/SP/PT. RES.
3-ARM CALIPER
TEMP. LOG
SONIC LOG

Permanent Datum GL Elev ____
Log Measured from GL 0 Ft. Above Permanent Datum
Drilling Measured from ____

Elevations: KB ____ DF ____ GL ____

Date	07/01/88			
Run No.	ONE			
Depth—Driller	944			
Depth—Logger	945			
Bottom Logged Interval	944			
Top Logged Interval	4			
Casing—Driller	NA @	@	@	@
Casing—Logger	NA			
Bit Size	6"			
Type Fluid in Hole	MUD			
Density and Viscosity				
pH and Fluid Loss	cc	cc	cc	cc
Source of Sample				
Rm @ Meas. Temp.	@ F	@ F	@ F	@ F
Rmf @ Meas. Temp.	@ F	@ °F	@ °F	@ °F
Rmc @ Meas. Temp.	@ F	@ °F	@ F	@ °F
Source of Rmf and Rmc				
Rm @ BHT	@ F	@ F	@ °F	@ °F
Time Since Circ.				
Max. Rec. Temp. Deg. F	87.6°F	F	°F	°F
Equip. No. and Location	102 ELKO			
Recorded By	SPØHR			
Witnessed By	MR. SEIGEL			

FOLD HERE

THIS HEADING AND LOG CONFORMS TO API RECOMMENDED STANDARD PRACTICE RP 31

Gamma Ray — Equipment Data — Density

Gamma Ray				Density			
Run No.	ONE			Run No.			
Tool Model No.				Tool Model No.			
Serial No.	GRS27A20			Serial No.			
Diam.	2 1/8"			Diam.			
Detect. Model No.				Computer Model No.			
Type				Serial No.			
Length				Source Model No.			
Dist. to Source				Serial No.			

General				Computer Data			
Hoist Truck No.	102						
Auxiliary Equipment							

Logging Data

General				Gamma Ray					Density			
Run No.	Depths From	Depths To	Speed Ft./Min.	T.C. Sec.	Sens. Settings	Zero Div. L or R	API G.R. Units Per Log Div.		T.C. Sec.	Density Scale	Correction Scale	Porosity Scale Data
1	944	4	20	3	400	2L						

Remarks:

Reference Literature:

SPONTANEOUS POTENTIAL Millivolts	DEPTH	RESISTIVITY Ohms m²/m	

5

\- | ↔ | +

GAMMA RAY

RADIATION INTENSITY INCREASES

30 API UNITS 180

5" = 100'

16" NORMAL

0 50 100

64" NORMAL

0 50 100

0 SINGLE POINT 100

0

GR

SP

100

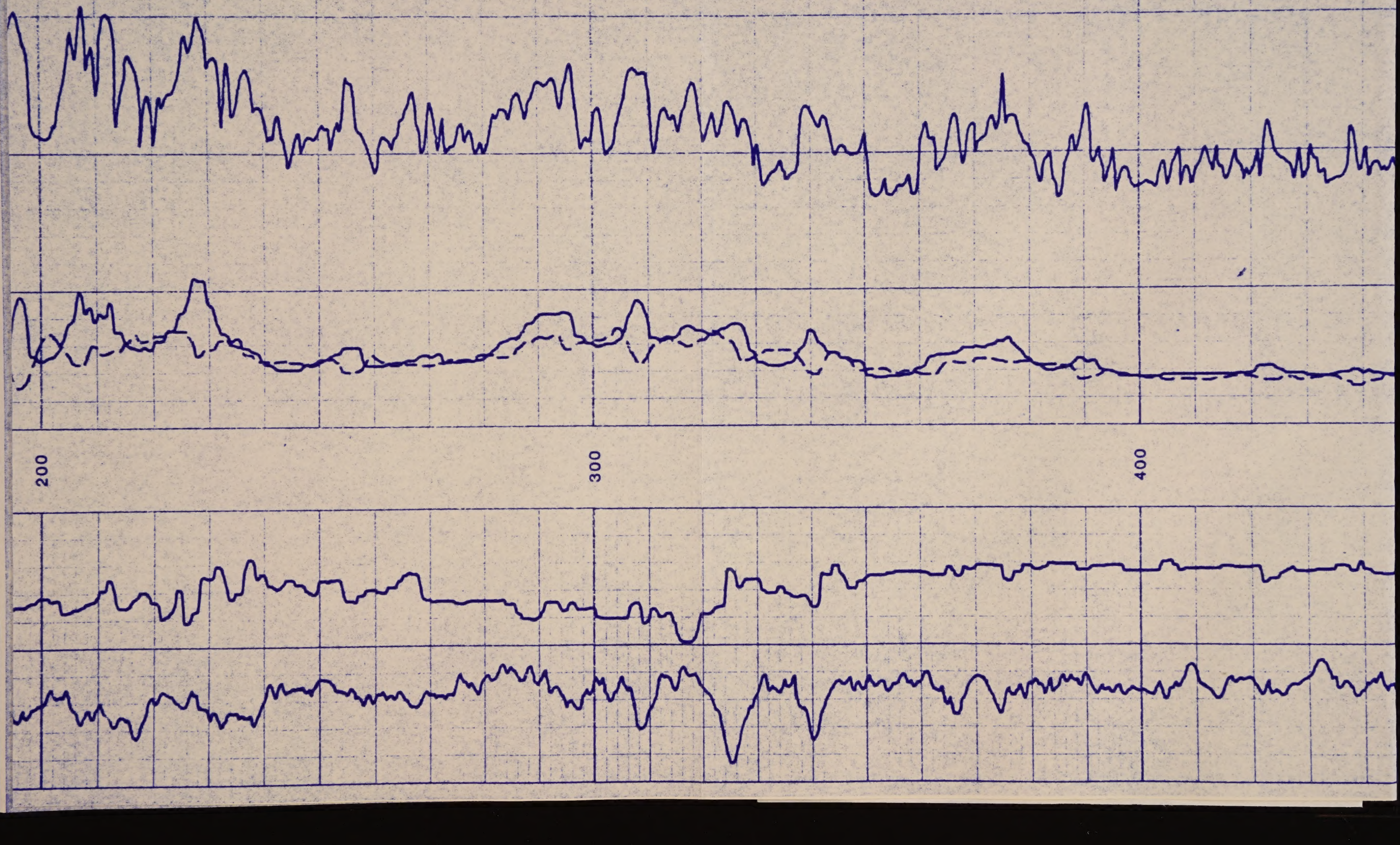
FLUID LEVEL

16"

64"

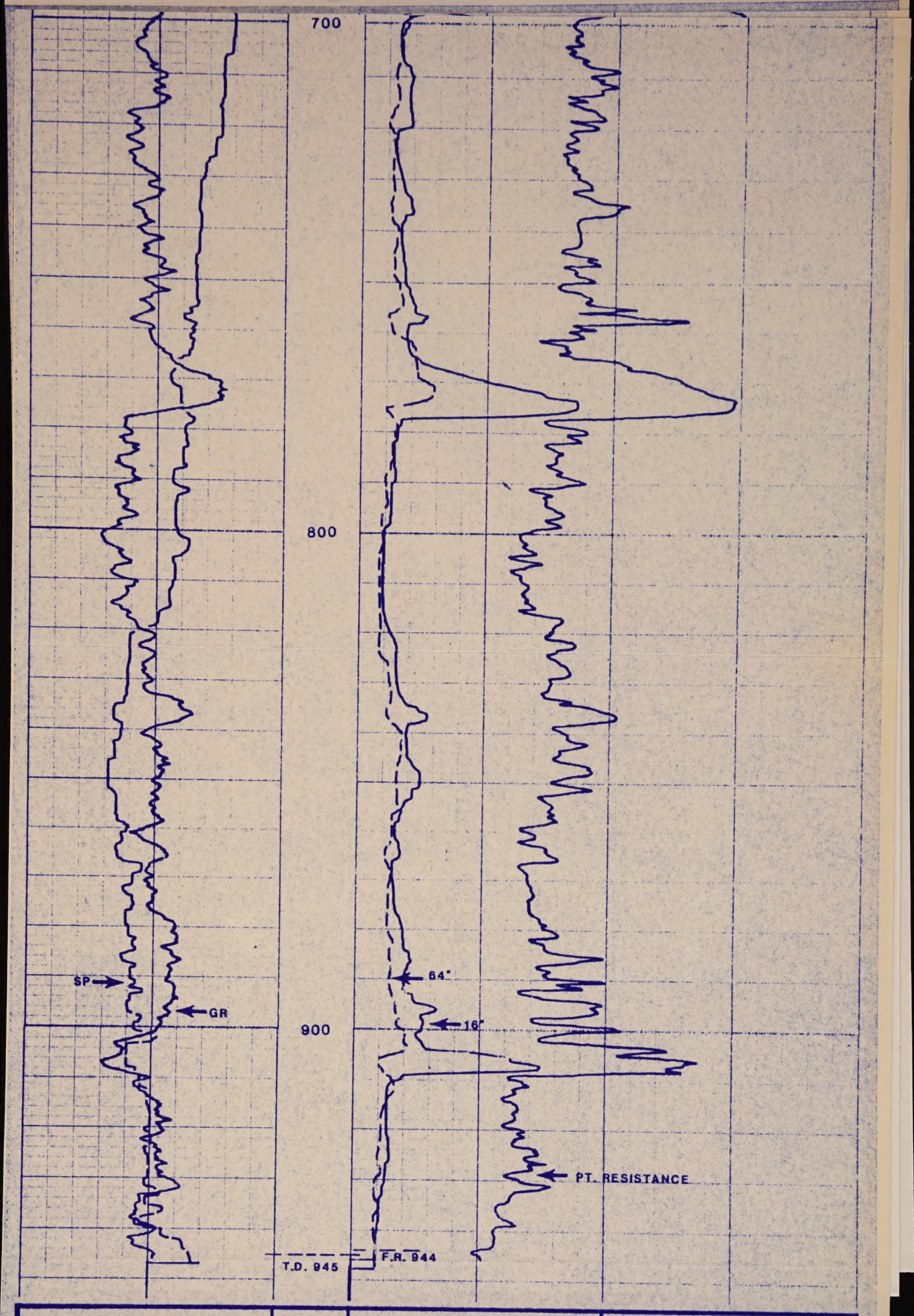
FLUID LEVEL

PT. RESISTANCE


200
300
400

500

800



30 API UNITS 180		0 SINGLE POINT 100
RADIATION INTENSITY INCREASES GAMMA RAY		0 64" NORMAL 50 100
− ↔ + 5		0 16" NORMAL 50 100
SPONTANEOUS POTENTIAL Millivolts	DEPTH	RESISTIVITY Ohms m²/m

Company	WOODWARD-CLYDE CONSULTANTS	Drillers T.D.	944
Well	MW-3	Log F.R.	944
Field	TOANA DRAW	Log T.D.	945
County	ELKO	Elevations:	
State	NEVADA	K.B. D.F.	G.L.

BLM Library
Denver Federal Center
Bldg. 50, OC-521
P.O. Box 25047
Denver, CO 80225

TD
195
.E4
E646
1989e
V.2

88076962

STRATA DATA INC

SONIC/CALIPER LOG

FILE NO. 5102

COMPANY WOODWARD-CLYDE CONSULTANTS

WELL MW-3

FIELD TOANA DRAW

COUNTY ELKO STATE NEVADA

LOCATION:

SEC ____ TWP ____ RGE ____

Other Services: GR/SP/DNEL, SINGLE PT. RES., 3-ARM CALIPER, TEMP.

Permanent Datum GL Elev. ____

Log Measured from GL, 0 Ft. Above Permanent Datum

Drilling Measured from ____

Elevations: KB ____ DF ____ GL ____

Date	07/01/88			
Run No.	ONE			
Depth—Driller	944			
Depth—Logger	945			
Bottom Logged Interval	939			
Top Logged Interval	6			
Casing—Driller	NA @	@	@	@
Casing—Logger	NA			
Bit Size	6"			
Type Fluid in Hole	MUD			
Density and Viscosity				
pH and Fluid Loss	cc	cc	cc	cc
Source of Sample				
Rm @ Meas. Temp.	@ °F	@ °F	@ °F	@ °F
Rmf @ Meas. Temp.	@ °F	@ °F	@ °F	@ °F
Rmc @ Meas. Temp.	@ °F	@ °F	@ °F	@ °F
Source of Rmf and Rmc				
Rm @ BHT	@ °F	@ °F	@ °F	@ °F
Time Since Circ.				
Max. Rec. Temp. Deg. F.	87.6 °F	°F	°F	°F
Equip. No. and Location	102 ELKO			
Recorded By	SPOHR			
Witnessed By	MR. SIEGEL			

FOLD HERE

THIS HEADING AND LOG CONFORMS TO API RECOMMENDED STANDARD PRACTICE RP-31

REMARKS

Changes in Mud Type or Additional Samples				
Date / Sample No.				
Depth-Driller				
Type Fluid in Hole				
Dens. / Visc.				
pH / Fluid Loss		cc		cc
Source of Sample				
Rm @ Meas. Temp.	@	°F	@	°F
Rmf @ Meas. Temp.	@	°F	@	°F
Rmc @ Meas. Temp.	@	°F	@	°F
Source Rmf / Rmc				
Rm @ BHT	@	°F	@	°F
Rmf @ BHT	@	°F	@	°F
Rmc @ BHT	@	°F	@	°F

Scale Changes

Type Log	Depth	Scale Up Hole	Scale Down Hole

Equipment Data

Run No.	Tool Type	Pad Type	Tool Position	Other

SONIC	DEPTH	CALIPER
μ SECONDS		HOLE DIAMETER INCHES
50 — 100		3 — 13 — 23

5" • 100'

0

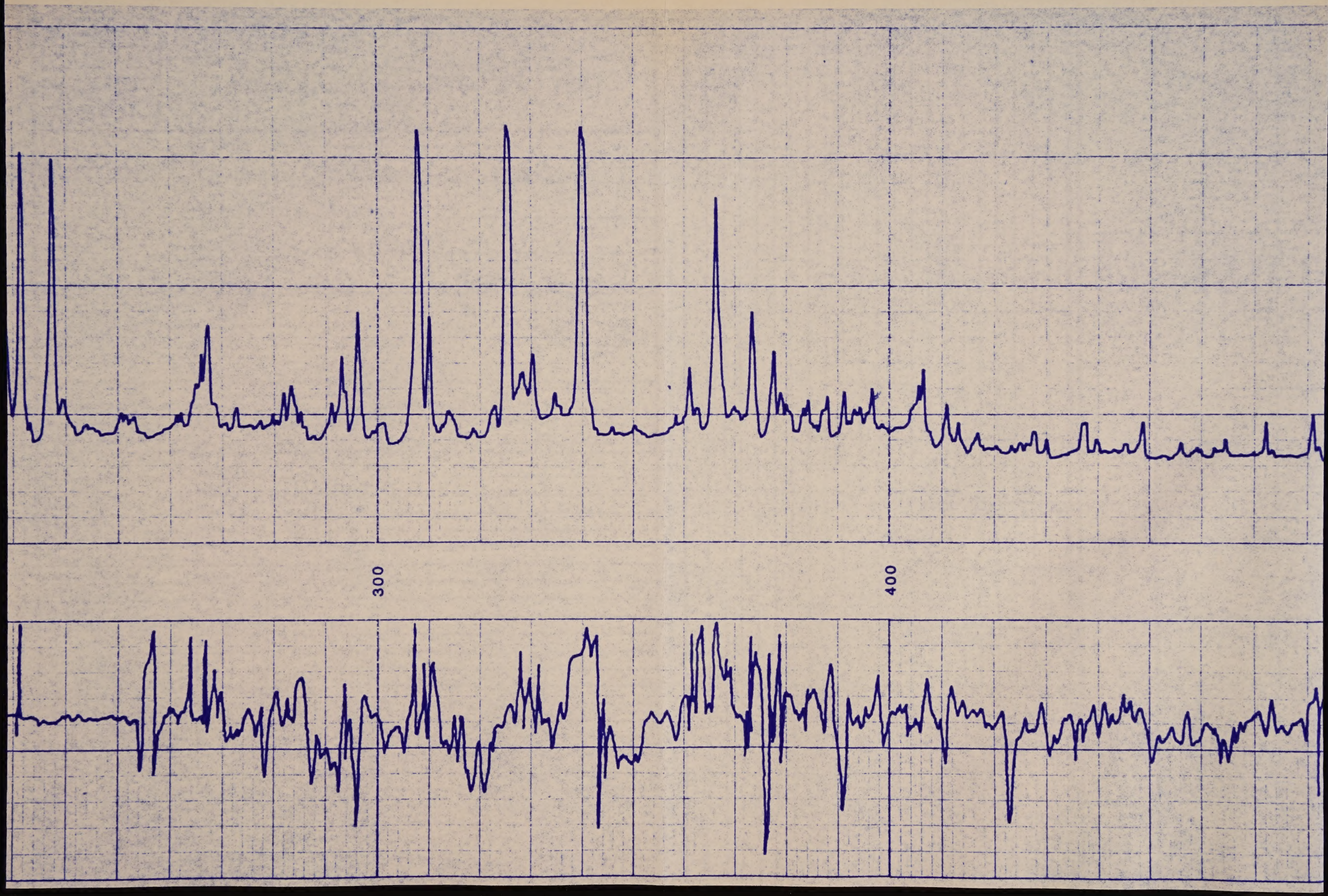
ΔT

Ø 5/8" CONDUCTOR CASING

CALIPER

100

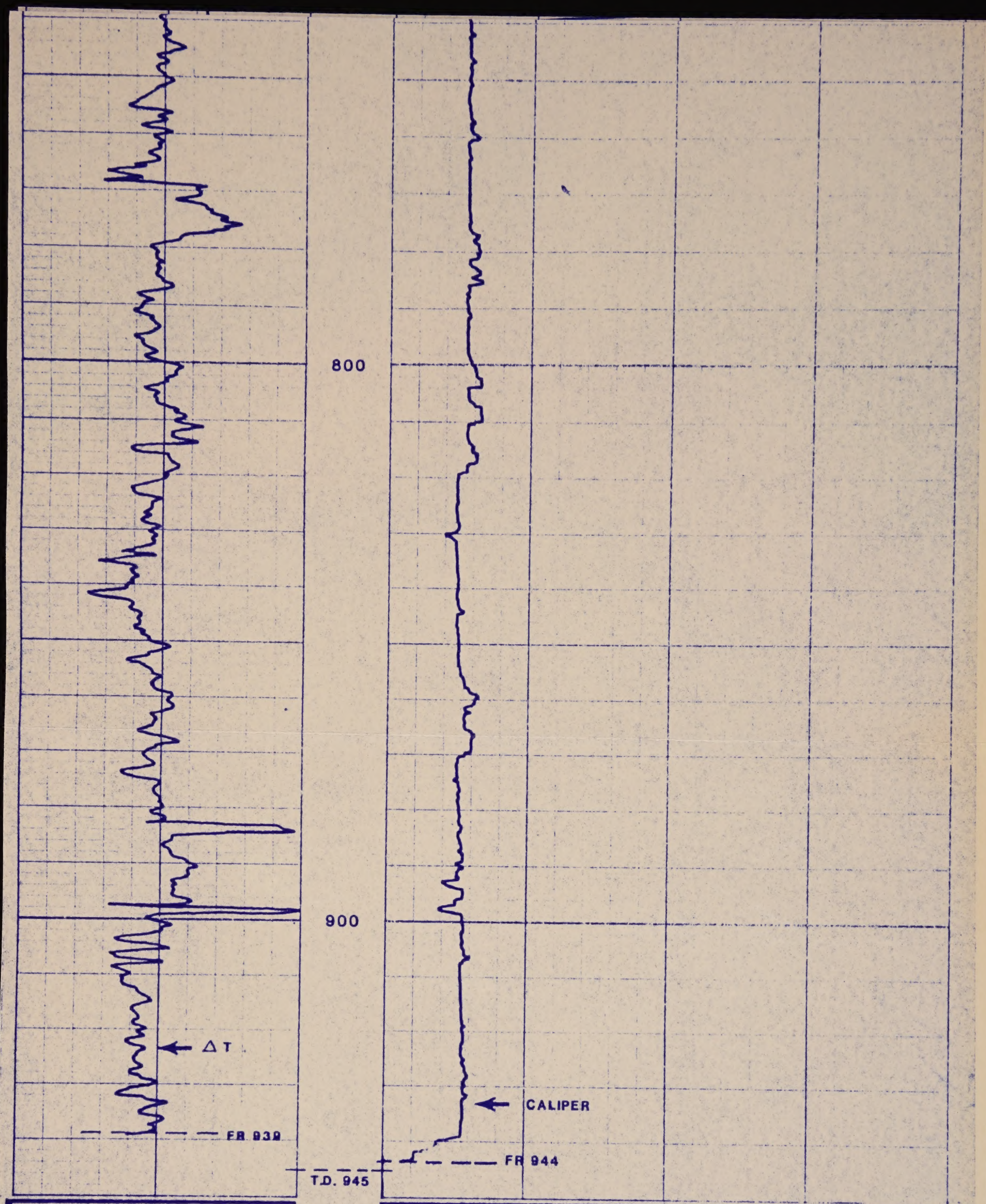
200


300
400

700

800

500



SONIC	DEPTH	CALIPER

Company	WOODWARD-CLYDE CONSULTANTS	Drillers T D	944
Well	MW-3	Log F R	944
Field	TOANA DRAW	Log T D	945
County	ELKO	Elevations:	
State	NEVADA	K B	D F G.L.

BLM Library
Denver Federal Center
Bldg. 50, OC-521
P.O. Box 25047
Denver, CO 80225

TD
195
.E4
E646
1989e
v.2

88076962

STRATA DATA INC

TEMPERATURE LOG
WITH DIFFERENTIAL TEMPERATURE

FILE NO 5102

COMPANY WOODWARD-CLYDE CONSULTANTS
WELL MW-3
FIELD TOANA DRAW
COUNTY ELKO STATE NEVADA
LOCATION:
SEC TWP RGE

Other Services
GR/SP/PT.RES.
DNEL
CALIPER
SONC

Elevations
KB
DF
GL

Permanent Datum GL
Log Measured from GL Ft. Above Permanent Datum 0
Drilling Measured from

Date	07/01/88		
Run No.	ONE		
Depth—Driller	944		
Depth—Logger	944		
Bottom Logged Interval	945		
Top Logged Interval	20		
Casing—Driller	NA		
Casing—Logger	NA		
Bit Size	6"		
Type Fluid in Hole	MUD		
Density and Viscosity			
pH and Fluid Loss		cc	
Source of Sample			
Rm @ Meas. Temp	@ F	@ F	
Rmf @ Meas. Temp	@ F	@ F	
Rmc @ Meas. Temp	@ F	@ F	
Source of Rmf and Rmc			
Rm @ BHT	@ F	@ F	
Time Since Circ.			
Max Rec. Temp. Deg. F	87.6°F		
Equip. No. and Location	ELKO 102		
Recorded By	SPOHR		
Witnessed By	MR. SIEGEL		

FOLD HERE

THIS HEADING AND LOG CONFORMS TO API RECOMMENDED STANDARD PRACTICE RP 1

REMARKS

Changes in Mud Type or Additional Samples

Date | Sample No.		
Depth-Driller		
Type Fluid in Hole		
Dens | Visc.		
pH | Fluid Loss	cc	cc
Source of Sample		
Rm @ Meas. Temp	@ F	@ F
Rmf @ Meas. Temp	@ F	@ F
Rmc @ Meas. Temp	@ F	@ F
Source Rmf | Rmc		
Rm @ BHT	@ F	@ F
Rmf @ BHT	@ F	@ F
Rmc @ BHT	@ F	@ F

Scale Changes

Type Log	Depth	Scale Up Hole	Scale Down Hole
TEMP.	806	60-80	80-100

Equipment Data

Run No.	Tool Type	Pad Type	Tool Position	Other
ONE	TEMP.	NA	FREE	COMPROBE

DIFFERENTIAL TEMPERATURE	DEPTH	TEMPERATURE DEGREES F
		TEMPERATURE INCREASES →

5" = 100'

60 70 80

0

FLUID LEVEL

100

200

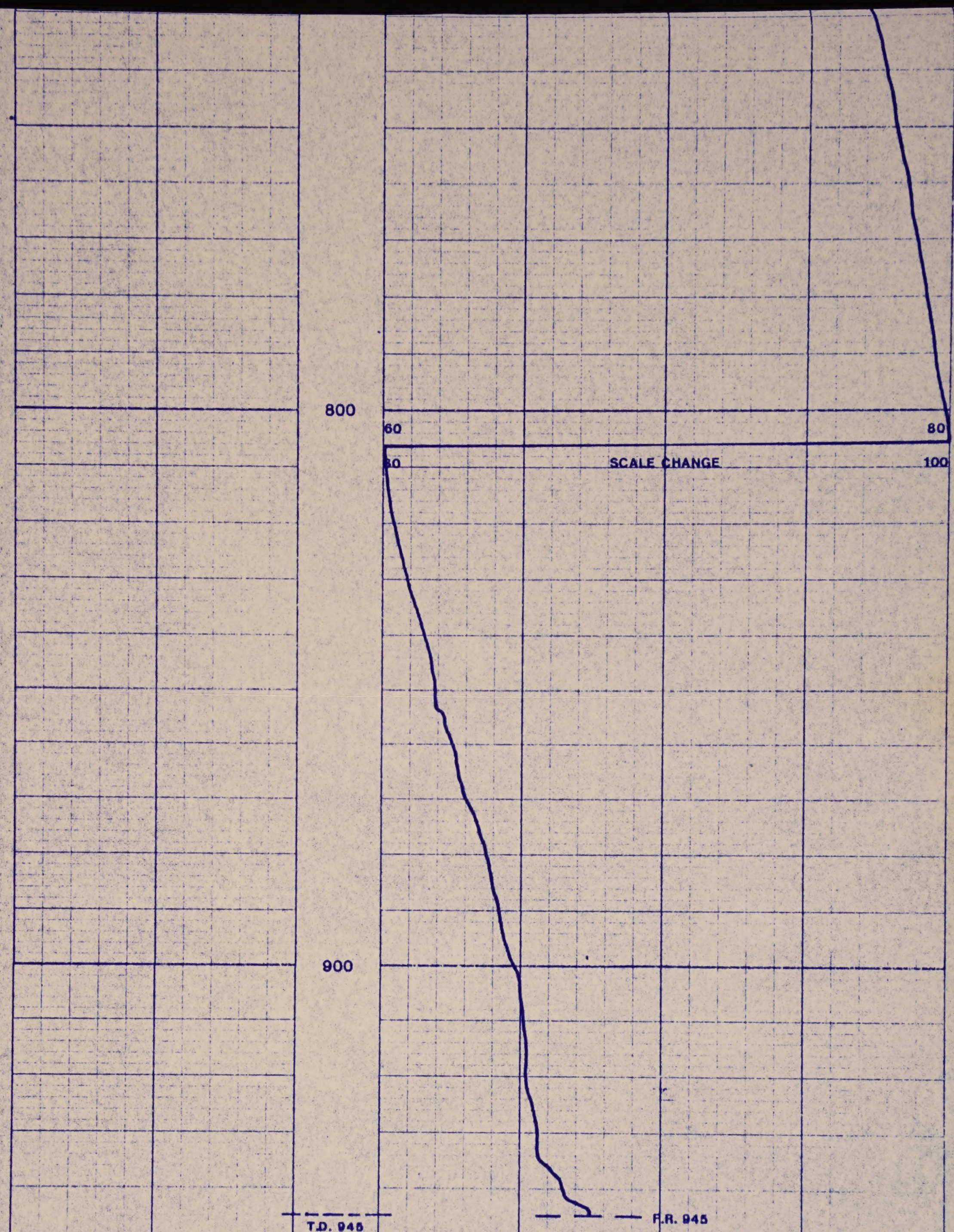
300

400

500

600

700



DIFFERENTIAL TEMPERATURE	DEPTH	TEMPERATURE DEGREES F

Company	WOODWARD-CLYDE CONSULTANTS	Drillers T.D.	944	
Well	MW-3	Log F.R.	945	
Field	TOANA DRAW	Log T.D.	945	
County	ELKO	Elevations:		
State	NEVADA	K.B.	D.F.	G.L.

BLM Library
Denver Federal Center
Bldg. 50, OC-521
P.O. Box 25047
Denver, CO 80225

TD
195
.E4
E646
1989e
v.2

88076962

STRATA DATA INC.

FILE NO. 5106

DUAL NORMAL ELECTRIC LOG WITH S.P. AND GAMMA RAY

COMPANY WOODWARD-CLYDE CONSULTANTS

WELL MW-4

FIELD TOANA DRAW

COUNTY ELKO STATE NEVADA

LOCATION:

SEC ___ TWP ___ RGE ___

Other Services: GR/SP/PT. RES. 3-ARM CALIPER TEMP. LOG SONIC LOG

Permanent Datum GROUND LEVEL Elev. ___

Log Measured from G.L. ___ Ft. Above Permanent Datum

Drilling Measured from G.L.

Elevations: KB ___ DF ___ GL ___

Date	07/17/88			
Run No.	ONE			
Depth—Driller	390			
Depth—Logger	375			
Bottom Logged Interval	374			
Top Logged Interval	4			
Casing—Driller	NA @	@	@	@
Casing—Logger	NA			
Bit Size	6 1/4"			
Type Fluid in Hole	FORM. WATER			
Density and Viscosity				
pH and Fluid Loss	cc	cc	cc	cc
Source of Sample				
Rm @ Meas. Temp.	@ °F	@ °F	@ °F	@ °F
Rmf @ Meas. Temp.	@ °F	@ °F	@ °F	@ °F
Rmc @ Meas. Temp.	@ °F	@ °F	@ °F	@ °F
Source of Rmf and Rmc				
Rm @ BHT	@ °F	@ °F	@ °F	@ °F
Time Since Circ.				
Max. Rec. Temp. Deg. F.	°F	°F	°F	°F
Equip. No. and Location	102 ELKO			
Recorded By	SPOHR			
Witnessed By	CASTELLANOS			

FOLD HERE

THIS HEADING AND LOG CONFORMS TO API RECOMMENDED STANDARD PRACTICE RP 31

Gamma Ray — Equipment Data — Density

Run No.	ONE			Run No.			
Tool Model No.				Tool Model No.			
Serial No.	GRS27A20			Serial No.			
Diam.	1 3/4"			Diam.			
Detect. Model No.	S-4			Computer Model No.			
Type	SCINT.			Serial No.			
Length	4"			Source Model No.			
Dist. to Source	N/A			Serial No.			

General — Computer Data

Hoist Truck No.	102					
Auxiliary Equipment						

Logging Data

General				Gamma Ray				Density			
Run No.	Depths From	Depths To	Speed Ft./Min.	T.C. Sec.	Sens. Settings	Zero Div. L or R	API G.R. Units Per Log Div.	T.C. Sec.	Density Scale	Correction Scale	Porosity Scale Data
1	374	4	20	3	500	2L					

Remarks:

Reference Literature:

SPONTANEOUS POTENTIAL Millivolts	DEPTH	RESISTIVITY Ohms m²/m	
		16" NORMAL	

2

GAMMA RAY

RADIATION INTENSITY INCREASES

24 API UNITS

5" = 100'

0 50 100

64" NORMAL

0 50 100

0

GR

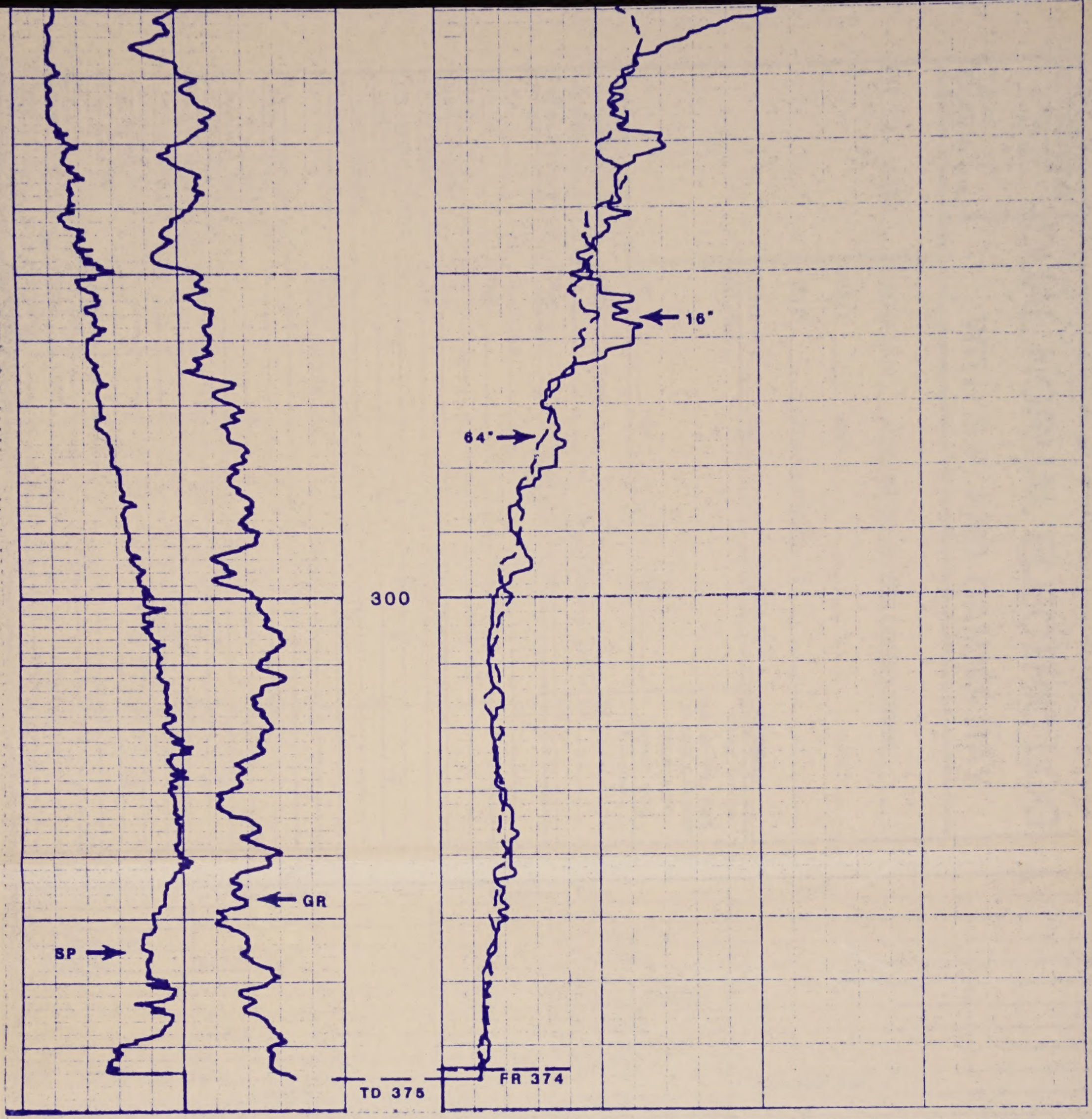
SP

16"

64"

100

200



24 API UNITS 148		
RADIATION INTENSITY INCREASES GAMMA RAY		
− 2 +		
SPONTANEOUS POTENTIAL Millivolts	DEPTH	RESISTIVITY Ohms m²/m

Company	WOODWARD–CLYDE CONSULTANTS		Drillers T.D.	390	
Well	MW-4		Log F.R.	374	
Field	TOANA DRAW		Log T.D.	375	
County	ELKO		Elevations:		
State	NEVADA		K.B.	D.F.	G.L.

BLM Library
Denver Federal Center
Bldg. 50, OC-521
P.O. Box 25047
Denver, CO 80225

TD
195
.E4
E646
1989e
v.2

88076962

STRATA DATA INC

SONIC/CALIPER LOG

FILE NO. 5108

COMPANY WOODWARD-CLYDE CONSULTANTS

WELL MW-4

FIELD TOANA DRAW

COUNTY ELKO STATE NEVADA

LOCATION:

SEC TWP RGE

Other Services
GR/SP/DNEL
SINGLE PT. RES.
3-ARM CALIPER
TEMP.

Permanent Datum GL Elev.
Log Measured from GL Ft. Above Permanent Datum
Drilling Measured from

Elevations:
KB
DF
GL

Date	07/17/88			
Run No.	ONE			
Depth—Driller	390			
Depth—Logger	375			
Bottom Logged Interval	374			
Top Logged Interval				
Casing—Driller	NA @	@	@	@
Casing—Logger	NA			
Bit Size	6 1/4			
Type Fluid in Hole	FORM WATER			
Density and Viscosity				
pH and Fluid Loss	cc	cc	cc	cc
Source of Sample				
Rm @ Meas. Temp.	@ °F	@ °F	@ °F	@ °F
Rmf @ Meas. Temp.	@ °F	@ °F	@ °F	@ °F
Rmc @ Meas. Temp.	@ °F	@ °F	@ °F	@ °F
Source of Rmf and Rmc				
Rm @ BHT	@ °F	@ °F	@ °F	@ °F
Time Since Circ.				
Max. Rec. Temp. Deg. F.	65.1°F			
Equip. No. and Location	102 ELKO			
Recorded By	SPOHR			
Witnessed By	CASTELLANOS			

FOLD HERE

THIS HEADING AND LOG CONFORMS TO API RECOMMENDED STANDARD PRACTICE RP-31

REMARKS

Changes in Mud Type or Additional Samples					
Date	Sample No.				
Depth-Driller					
Type Fluid in Hole					
Dens.	Visc.				
pH	Fluid Loss		cc		cc
Source of Sample					
Rm @ Meas. Temp.		@ °F		@ °F	
Rmf @ Meas. Temp.		@ °F		@ °F	
Rmc @ Meas. Temp.		@ °F		@ °F	
Source Rmf	Rmc				
Rm @ BHT		@ °F		@ °F	
Rmf @ BHT		@ °F		@ °F	
Rmc @ BHT		@ °F		@ °F	

Scale Changes			
Type Log	Depth	Scale Up Hole	Scale Down Hole

Equipment Data				
Run No.	Tool Type	Pad Type	Tool Position	Other

	DEPTH	CALIPER
		HOLE DIAMETER INCHES 3 13 23

SONIC

5" = 100 '

100 μSECONDS 200

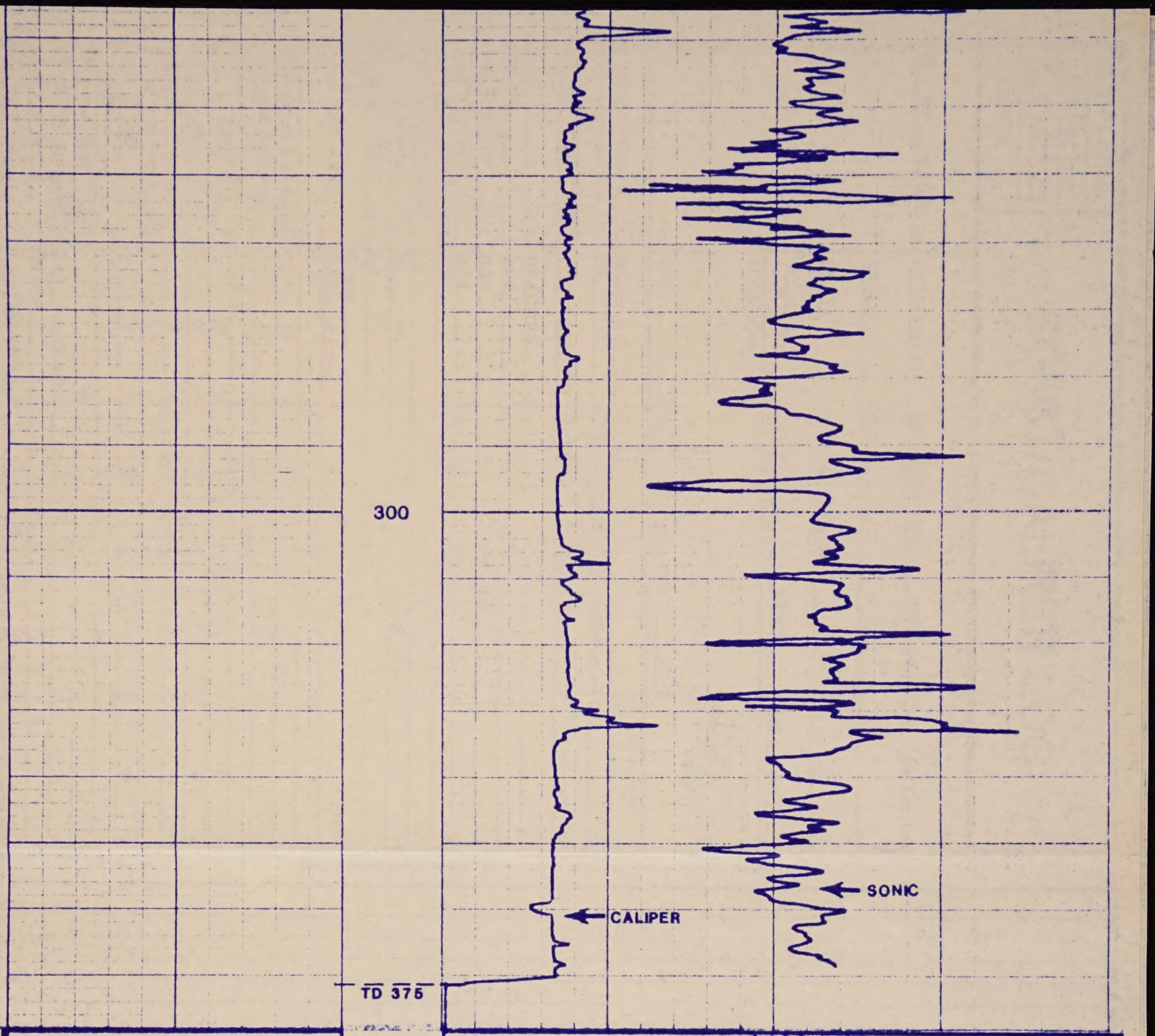
0

CALIPER

SONIC

100

200



DEPTH

CALIPER

Company	**WOODWARD CLYDE CONSULTANTS**	Drillers T D	**380**	
Well	**MW-4**	Log F R	**374**	
Field	**TOANA DRAW**	Log T D	**375**	
County	**ELKO**	Elevations:		
State	**NEVADA**	K B	D F	G.L.

BLM Library
Denver Federal Center
Bldg. 50, OC-521
P.O. Box 25047
Denver, CO 80225

TD
195
.E4
.E646
1989e
v.2

88076962

STRATA DATA INC

TEMPERATURE LOG
WITH DIFFERENTIAL TEMPERATURE

FILE NO 5106

COMPANY WOODWARD CLYDE CONSULTANTS

WELL MW-4

FIELD TOANA DRAW

COUNTY ELKO STATE NEVADA

LOCATION:

SEC ____ TWP ____ RGE ____

Other Services
GR/SP/PT. RES.
DNEL
CALIPER
SONIC

Permanent Datum GL Elev ____
Log Measured from GL 0 Ft. Above Permanent Datum
Drilling Measured from ____

Elevations
KB ____
DF ____
GL ____

Date	7/17/88				
Run No.	ONE				
Depth—Driller	390				
Depth—Logger	375				
Bottom Logged Interval	375				
Top Logged Interval	20				
Casing—Driller	NA @	@	@	@	
Casing—Logger	NA				
Bit Size	6 1/4"				
Type Fluid in Hole	MUD				
Density and Viscosity					
pH and Fluid Loss	cc	cc	cc	cc	
Source of Sample					
Rm @ Meas. Temp.	@ F	@ F	@ F	@ F	
Rmf @ Meas. Temp	@ F	@ F	@ F	@ F	
Rmc @ Meas. Temp.	@ F	@ F	@ F	@ F	
Source of Rmf and Rmc					
Rm @ BHT	@ F	@ F	@ F	@ F	
Time Since Circ					
Max. Rec. Temp. Deg. F.	85.1°F	F	°F	F	
Equip. No. and Location	102 ELKO				
Recorded By	SPOHR				
Witnessed By	CASTELLANOS				

FOLD HERE ↓

THIS HEADING AND LOG CONFORMS TO API RECOMMENDED STANDARD PRACTICE RP 31

REMARKS ____

Scale Changes
Type Log | Depth | Scale Up Hole | Scale Down Hole

Equipment Data
Tool Type | Pad Type | Tool Position | Other
TEMP. | NA | FREE | COMPROBE

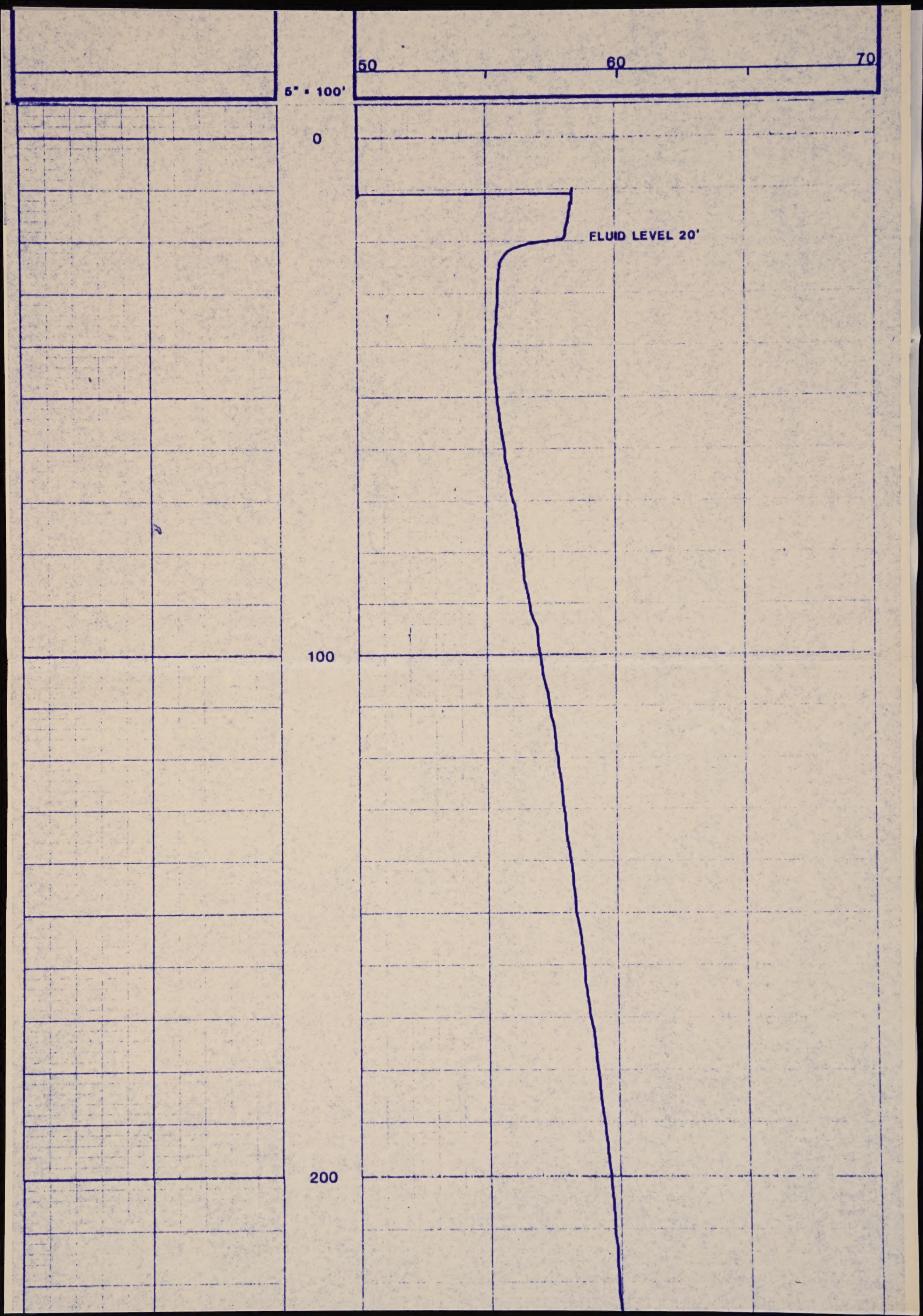
Changes in Mud Type or Additional Samples
Date | Sample No. | Run No.
Depth-Driller | ONE
Type Fluid in Hole
Dens | Visc. | cc
pH | Fluid Loss | cc
Source of Sample
Rm @ Meas. Temp. @ °F @ °F @ °F
Rmf @ Meas. Temp. @ °F @ °F @ °F
Rmc @ Meas. Temp. @ °F @ °F @ °F
Source Rmf | Rmc
Rm @ BHT @ °F @ °F
Rmf @ BHT @ °F @ °F
Rmc @ BHT @ °F @ °F

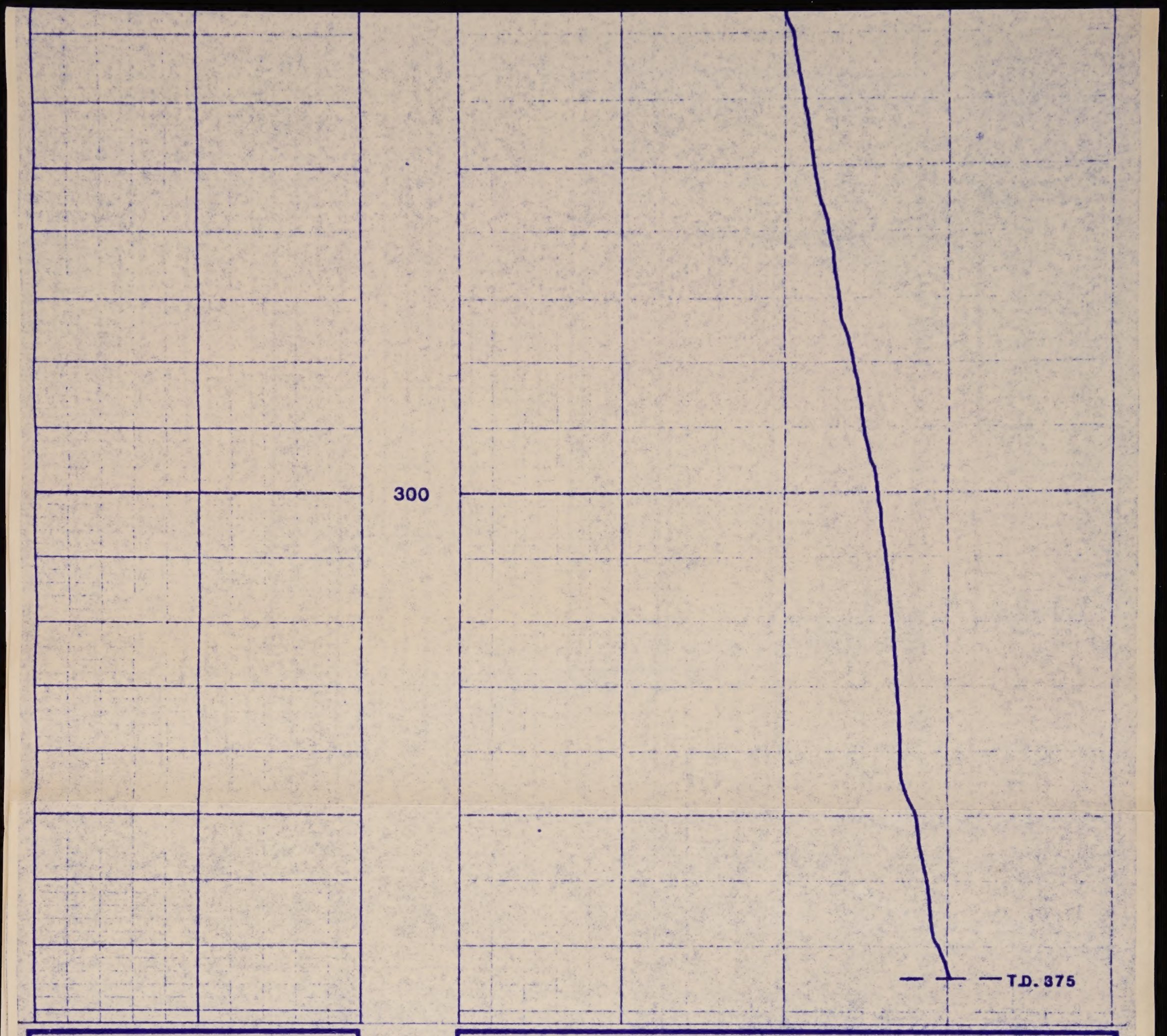
TEMPERATURE
DEGREES F

TEMPERATURE INCREASES →

DEPTH

DIFFERENTIAL TEMPERATURE


50
60
70
5" = 100'
0
FLUID LEVEL 20'
100
200



50 60 70

TEMPERATURE INCREASES

DIFFERENTIAL TEMPERATURE	DEPTH	TEMPERATURE DEGREES F

Company	WOODWARD-CLYDE CONSULTANTS	Drillers T.D.	390
Well	MW-4	Log F.R.	375
Field	TOANA DRAW	Log T.D.	375
County	ELKO	Elevations:	
State	NEVADA	K.B.	D.F. G.L.

BLM Library
Denver Federal Center
Bldg. 50, OC-521
P.O. Box 25047
Denver, CO 80225

TD
195
.E4
E646
1989e
v.2

88076962

STRATA

DATA INC

DUAL NORMAL ELECTRIC LOG WITH S.P. AND GAMMA RAY

FILE NO 5107

COMPANY WOODWARD-CLYDE CONSULTANTS

WELL MW-5

FIELD TOANA DRAW

COUNTY ELKO STATE NEVADA

LOCATION:

SEC TWP RGE

Other Services
3-ARM CALIPER
TEMP. LOG
SONIC LOG

Elevations
KB
DF
GL

Permanent Datum GL
Log Measured from GL
Drilling Measured from

Elev.
Ft. Above Permanent Datum

Date	07/21/88		
Run No	ONE		
Depth—Driller	285		
Depth—Logger	284		
Bottom Logged Interval	283		
Top Logged Interval	4		
Casing—Driller	NA @	@	@
Casing—Logger	NA		
Bit Size	6"		
Type Fluid in Hole	FORM. WATER		
Density and Viscosity			
pH and Fluid Loss		cc	cc
Source of Sample			
Rm @ Meas. Temp	@ °F	@ °F	@ °F
Rmf @ Meas. Temp	@ °F	@ °F	@ °F
Rmc @ Meas. Temp.	@ °F	@ °F	@ °F
Source of Rmf and Rmc			
Rm @ BHT	@ °F	@ °F	@ °F
Time Since Circ.			
Max. Rec. Temp. Deg. F.		°F	°F
Equip. No. and Location	102 ELKO		
Recorded By	SPOHR		
Witnessed By	MR. RAYMOND		

FOLD HERE

THIS HEADING AND LOG CONFORMS TO API RECOMMENDED STANDARD PRACTICE RP 31

Gamma Ray — Equipment Data — Density

Run No.	ONE			Run No.			
Tool Model No.				Tool Model No.			
Serial No.	GRS27A20			Serial No.			
Diam.	2 1/8"			Diam.			
Detect. Model No.				Computer Model No.			
Type				Serial No.			
Length				Source Model No.			
Dist. to Source				Serial No.			

General — Computer Data

Hoist Truck No.	102						
Auxiliary Equipment							

Logging Data

Run No.	Depths From	Depths To	Speed Ft./Min.	Gamma Ray T.C. Sec.	Gamma Ray Sens. Settings	Gamma Ray Zero Div. L or R	Gamma Ray API G.R. Units Per Log Div.	Density T.C. Sec.	Density Density Scale	Density Correction Scale	Density Porosity Scale Data
1	283	4	20	3	500	2L					

Remarks:

Reference Literature:

SPONTANEOUS POTENTIAL Millivolts	DEPTH	RESISTIVITY Ohms m²/m	
		16" NORMAL	

2

GAMMA RAY

RADIATION INTENSITY INCREASES

24 API UNITS 148

0 50 100

64" NORMAL

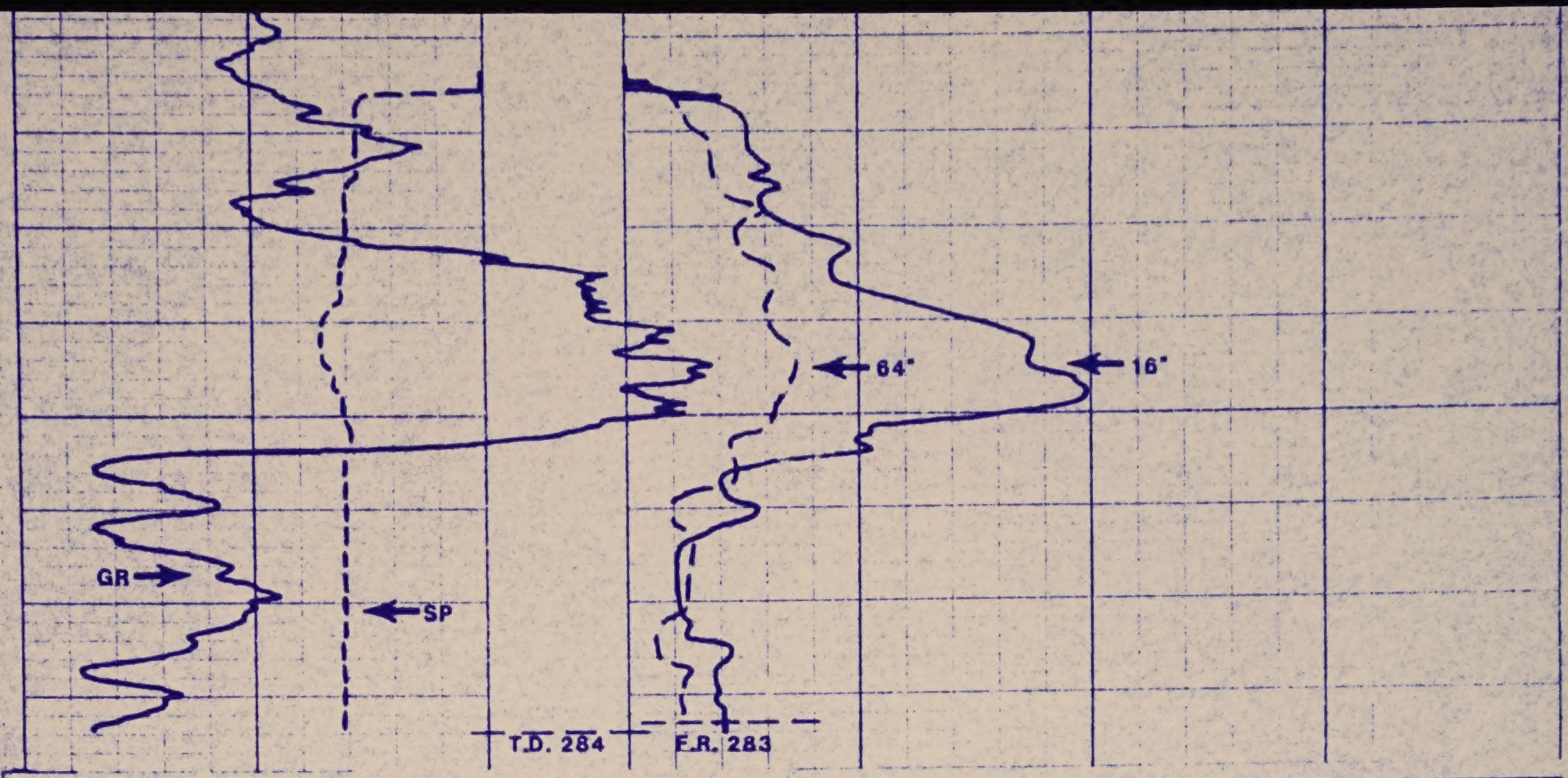
0 50 100

GR

0

100

200



24 API UNITS 148		0 64" NORMAL 50 100
RADIATION INTENSITY INCREASES GAMMA RAY		0 16" NORMAL 50 100
− 2 +		
SPONTANEOUS POTENTIAL Millivolts	DEPTH	RESISTIVITY Ohms m^2/m

Company	WOODWARD–CLYDE CONSULTANTS	Drillers T.D.	285
Well	MW–5	Log F.R.	283
Field	TOANA DRAW	Log T.D.	284
County	ELKO	Elevations:	
State	NEVADA	K.B. D.F. G.L.	

BLM Library
Denver Federal Center
Bldg. 50, OC-521
P.O. Box 25047
Denver, CO 80225

TD
195
.E4
E646
1989e
v.2

88076962

STRATA DATA INC

SONIC/CALIPER LOG

FILE NO. 5107

COMPANY WOODWARD-CLYDE CONSULTANTS

WELL MW-5

FIELD TOANA DRAW

COUNTY ELKO STATE NEVADA

LOCATION:

SEC _____ TWP _____ RGE _____

Other Services

GR/SP/DNEL
3-ARM CALIPER
TEMP.

Permanent Datum GL Elev. _____

Log Measured from GL , 0 Ft. Above Permanent Datum

Drilling Measured from _____

Elevations:

KB _____

DF _____

GL _____

Date	07/21/88			
Run No.	ONE			
Depth—Driller	285			
Depth—Logger	284			
Bottom Logged Interval	283			
Top Logged Interval	4			
Casing—Driller	NA @	@	@	@
Casing—Logger	NA			
Bit Size	6"			
Type Fluid in Hole	FORM WATER			
Density and Viscosity				
pH and Fluid Loss	cc	cc	cc	cc
Source of Sample				
Rm @ Meas. Temp.	@ °F	@ °F	@ °F	@ °F
Rmf @ Meas. Temp.	@ °F	@ °F	@ °F	@ °F
Rmc @ Meas. Temp.	@ °F	@ °F	@ °F	@ °F
Source of Rmf and Rmc				
Rm @ BHT	@ °F	@ °F	@ °F	@ °F
Time Since Circ.				
Max. Rec. Temp. Deg. F.	°F	°F	°F	°F
Equip. No. and Location	102 ELKO			
Recorded By	SPOHR			
Witnessed By	MR. RAYMOND			

FOLD HERE

THIS HEADING AND LOG CONFORMS TO API RECOMMENDED STANDARD PRACTICE RP-31

REMARKS _____

Scale Changes: Type Log | Depth | Scale Up Hole | Scale Down Hole

Equipment Data: Tool Type | Run No. | Pad Type | Tool Position | Other

Changes in Mud Type or Additional Samples: Date | Sample No. | Depth-Driller | Type Fluid in Hole | Dens. | Visc. | pH | Fluid Loss | Source of Sample | Rm @ Meas. Temp. | Rmf @ Meas. Temp. | Rmc @ Meas. Temp. | Source Rmf | Rmc | Rm @ BHT | Rmf @ BHT | Rmc @ BHT

CALIPER

HOLE DIAMETER
INCHES
13 | 23

DEPTH

3

5" = 100'

SONIC

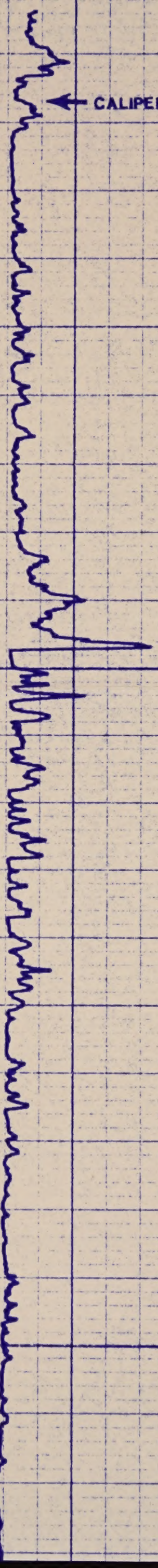
100 SECONDS 200

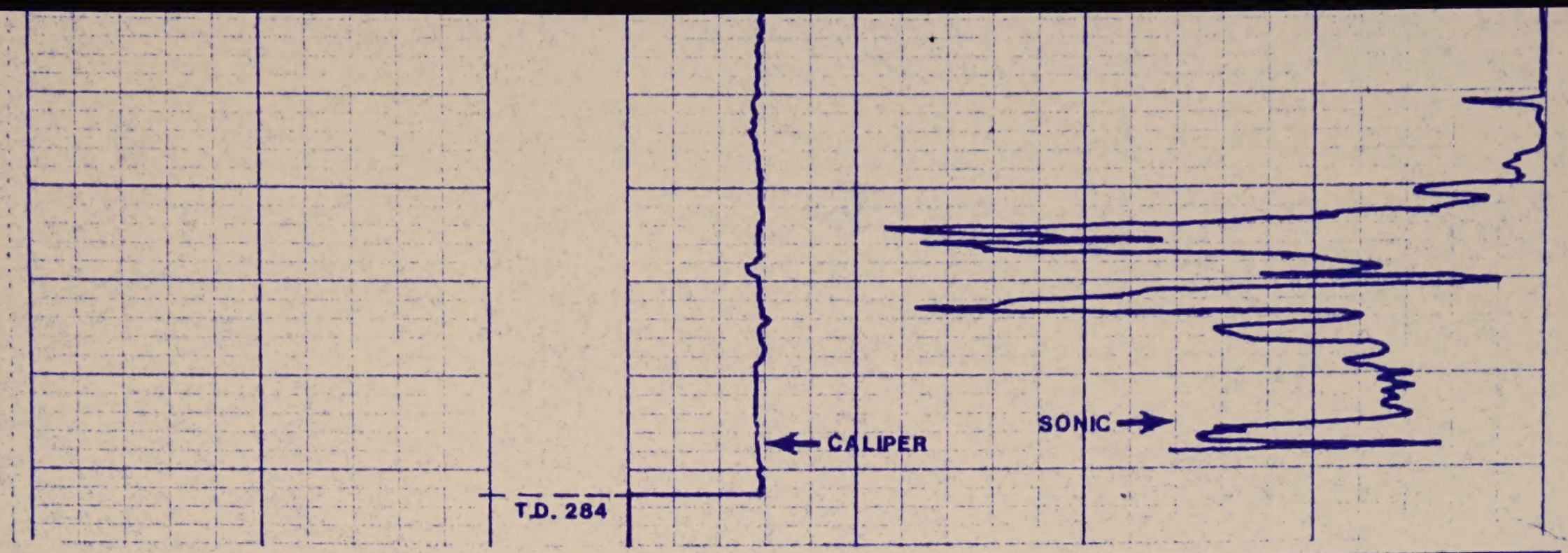
0

CALIPER

100

200





100 μ SECONDS 200

SONIC

3 1/3 23

HOLE DIAMETER
INCHES

DEPTH

CALIPER

Company	WOODWARD–CLYDE CONSULTANTS		Drillers T.D.	285	
Well	MW–5		Log F R	283	
Field	TOANA DRAW		Log T D.	284	
County	ELKO		Elevations:		
State	NEVADA		K.B.	D F.	G.L.

BLM Library
Denver Federal Center
Bldg. 50, OC-521
P.O. Box 25047
Denver, CO 80225

TD
195
.E4
E646
1989e
v.2

88076962

STRATA DATA INC

TEMPERATURE LOG
WITH DIFFERENTIAL TEMPERATURE

FILE NO 5107

COMPANY WOODWARD-CLYDE CONSULTANTS

WELL MW-5

FIELD TOANA DRAW

COUNTY ELKO STATE NEVADA

LOCATION:

SEC _____ TWP _____ RGE _____

Other Services
GR/SP/DNEL
3-ARM CALIPER
SONIC

Permanent Datum GL Elev _____
Log Measured from GL 0 Ft. Above Permanent Datum
Drilling Measured from _____

Elevations
KB _____
DF _____
GL _____

Date	07/21/88				
Run No	ONE				
Depth—Driller	285				
Depth—Logger	284				
Bottom Logged Interval	284				
Top Logged Interval	200				
Casing—Driller	NA @	@	@	@	
Casing—Logger	NA				
Bit Size	6"				
Type Fluid in Hole	FORM. WATER				
Density and Viscosity					
pH and Fluid Loss	cc	cc	cc	cc	
Source of Sample					
Rm @ Meas. Temp.	@ F	@ F	@ F	@ F	
Rmf @ Meas. Temp.	@ F	@ F	@ F	@ F	
Rmc @ Meas. Temp.	@ F	@ F	@ F	@ F	
Source of Rmf and Rmc					
Rm @ BHT	@ F	@ F	@ F	@ F	
Time Since Circ.					
Max. Rec. Temp. Deg. F.	57.1°F	F	°F	F	
Equip. No. and Location	102 ELKO				
Recorded By	SPOHR				
Witnessed By	MR. RAYMOND				

FOLD HERE

THIS HEADING AND LOG CONFORMS TO API RECOMMENDED STANDARD PRACTICE RP 31

REMARKS _____

Scale Changes
Scale Up Hole
Scale Down Hole
Depth

Equipment Data
Other
Pad Type: NA
Tool Position: FREE
COMPROBE

Type Log

Tool Type: TEMP.
Run No.: ONE

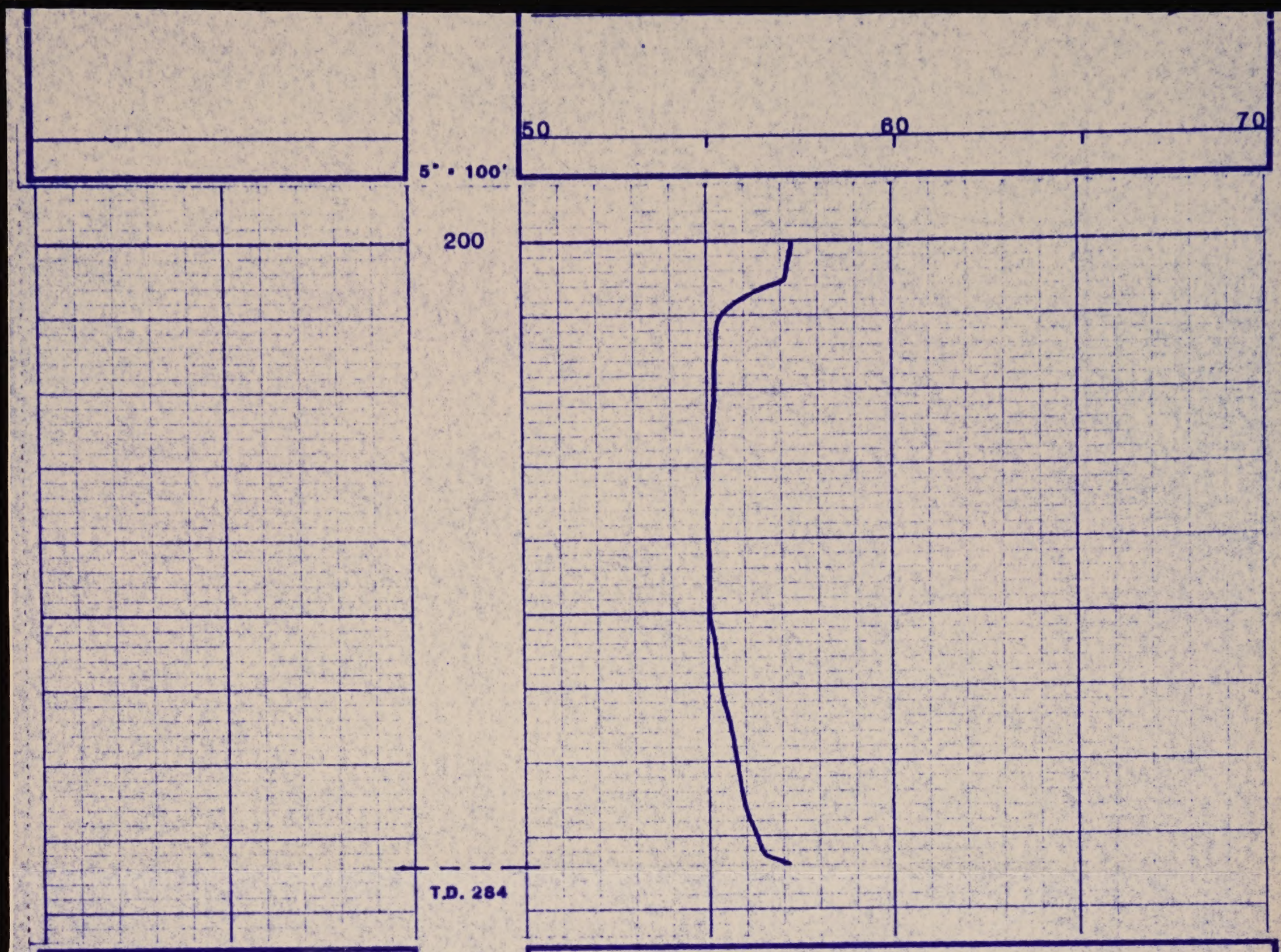
Changes in Mud Type or Additional Samples
Date | Sample No.
Depth-Driller
Type Fluid in Hole
Dens. | Visc.
pH | Fluid Loss
Source of Sample
Rm @ Meas. Temp.
Rmf @ Meas. Temp.
Rmc @ Meas. Temp.
Source Rmf | Rmc
Rm @ BHT
Rmf @ BHT
Rmc @ BHT

TEMPERATURE
DEGREES F

TEMPERATURE INCREASES

DEPTH

DIFFERENTIAL TEMPERATURE



Company **WOODWARD-CLYDE CONSULTANTS**

Well **MW-5**

Field **TOANA DRAW**

County **ELKO**

State **NEVADA**

Drillers T.D. **285**

Log F.R. **284**

Log T.D. **284**

Elevations:

K.B. D.F. G.L.

BLM Library
Denver Federal Center
Bldg. 50, OC-521
P.O. Box 25047
Denver, CO 80225

TD
195
.E4
E64b
1989e
V.2
88076962

STRATA DATA INC.

DUAL NORMAL ELECTRIC LOG WITH S.P. AND GAMMA RAY

FILE NO. 5110

COMPANY WOODWARD-CLYDE CONSULTANTS

WELL MW-8

FIELD TOANA DRAW

COUNTY ELKO STATE NEVADA

LOCATION:

SEC 19 TWP 42N RGE 66E

Other Services

SONIC/CAL. LOG
TEMP.LOG

Elevations:

KB
DF
GL

Permanent Datum GROUND LEVEL Elev.
Log Measured from G.L. 0 Ft. Above Permanent Datum
Drilling Measured from G.L.

Date	08/04/88																						
Run No.	ONE																						
Depth—Driller	688'																						
Depth—Logger	688																						
Bottom Logged Interval	688																						
Top Logged Interval	0																						
Casing—Driller	@																						
Casing—Logger																							
Bit Size	8"																						
Type Fluid in Hole	MUD																						
Density and Viscosity																							
pH and Fluid Loss		cc																					
Source of Sample	PIT																						
Rm @ Meas. Temp.	5.7 @ 100 °F	@ °F	@ °F	@ °F	@ °F	@ °F	@ °F	@ °F	@ °F	@ °F	@ °F	@ °F	@ °F	@ °F	@ °F	@ °F	@ °F	@ °F	@ °F	@ °F	@ °F	@ °F	@ °F
Rmf @ Meas. Temp.	@ °F	@ °F	@ °F	@ °F	@ °F	@ °F	@ °F	@ °F	@ °F	@ °F	@ °F	@ °F	@ °F	@ °F	@ °F	@ °F	@ °F	@ °F	@ °F	@ °F	@ °F	@ °F	@ °F
Rmc @ Meas. Temp.	@ °F	@ °F	@ °F	@ °F	@ °F	@ °F	@ °F	@ °F	@ °F	@ °F	@ °F	@ °F	@ °F	@ °F	@ °F	@ °F	@ °F	@ °F	@ °F	@ °F	@ °F	@ °F	@ °F
Source of Rmf and Rmc																							
Rm @ BHT	8.05 @ 70.8 °F	@ °F	@ °F	@ °F	@ °F	@ °F	@ °F	@ °F	@ °F	@ °F	@ °F	@ °F	@ °F	@ °F	@ °F	@ °F	@ °F	@ °F	@ °F	@ °F	@ °F	@ °F	@ °F
Time Since Circ.	3 HRS.																						
Max. Rec. Temp. Deg. F.	70.8 °F																						
Equip. No. and Location	102 ELKO																						
Recorded By	MC DONALD																						
Witnessed By	MR. MERRELL																						

FOLD HERE ↓

THIS HEADING AND LOG CONFORMS TO API RECOMMENDED STANDARD PRACTICE RP-31

Gamma Ray — Equipment Data — Density								
Run No.	ONE			Run No.				
Tool Model No.	GRS27A20			Tool Model No.				
Serial No.	118			Serial No.				
Diam.	1 3/4			Diam.				
Detect. Model No.	S4			Computer Model No.				
Type	SCINT.			Serial No.				
Length	4"			Source Model No.				
Dist. to Source	N/A			Serial No.				
General				Computer Data				
Hoist Truck No.	102							
Auxiliary Equipment								

Logging Data

General				Gamma Ray				Density			
Run No.	Depths From	Depths To	Speed Ft./Min.	T.C. Sec.	Sens. Settings	Zero Div. L or R	API G.R. Units Per Log Div.	T.C. Sec.	Density Scale	Correction Scale	Porosity Scale Data
1	0	688	20	3	235	4L	12				

Remarks:	Reference Literature:

SPONTANEOUS POTENTIAL Millivolts	DEPTH	RESISTIVITY Ohms m^2/m	

5

\- +

GAMMA RAY

RADIATION INTENSITY INCREASES

48 API UNITS 168

5" = 100'

16" NORMAL

0 50 100

64" NORMAL

0 50 100

0

GR

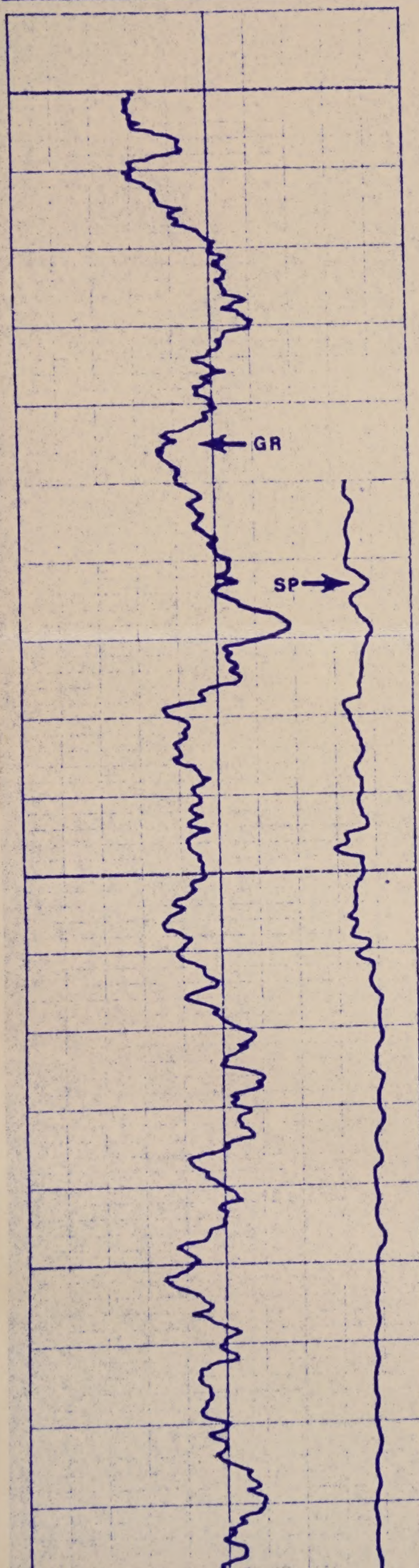
SP

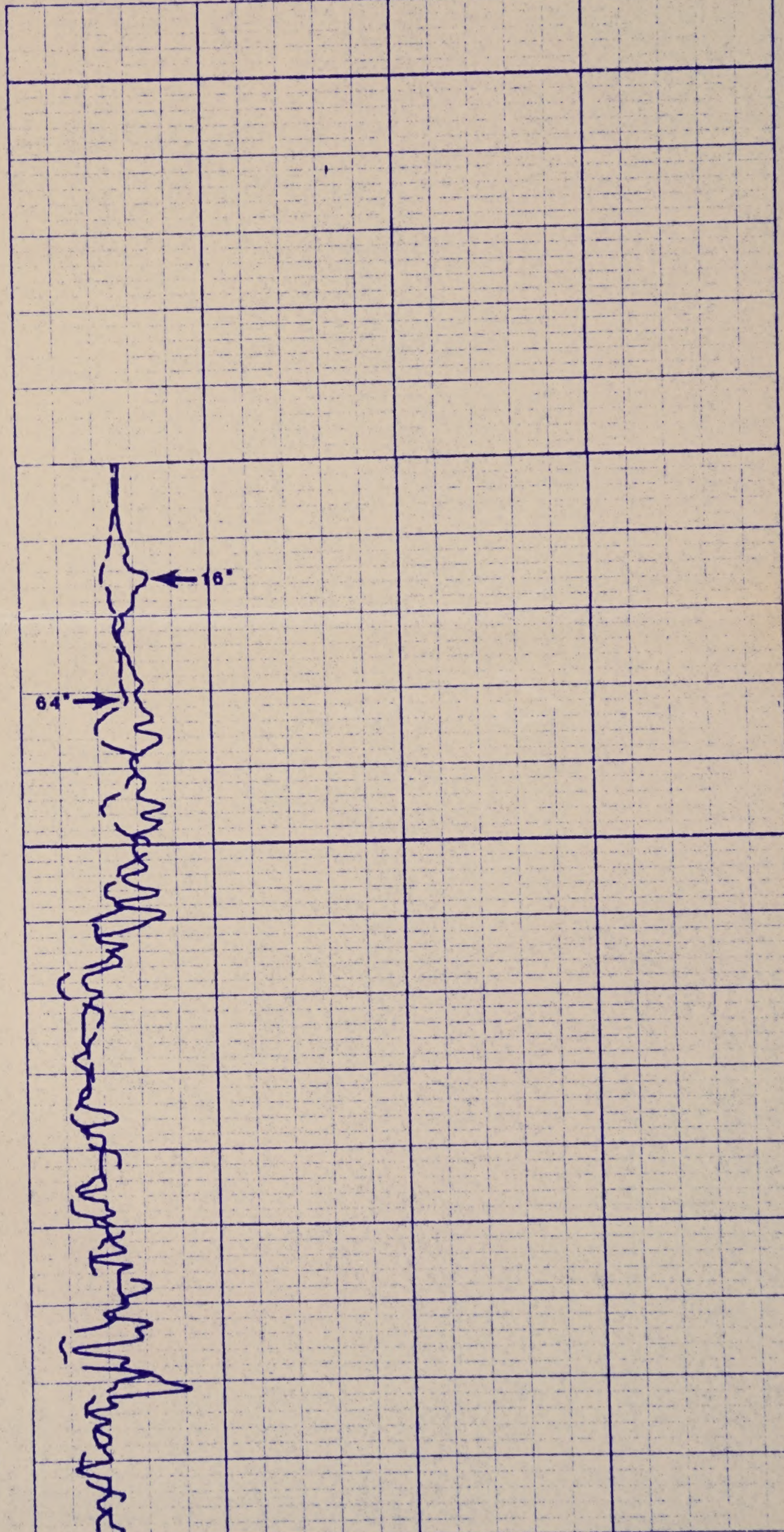
16"

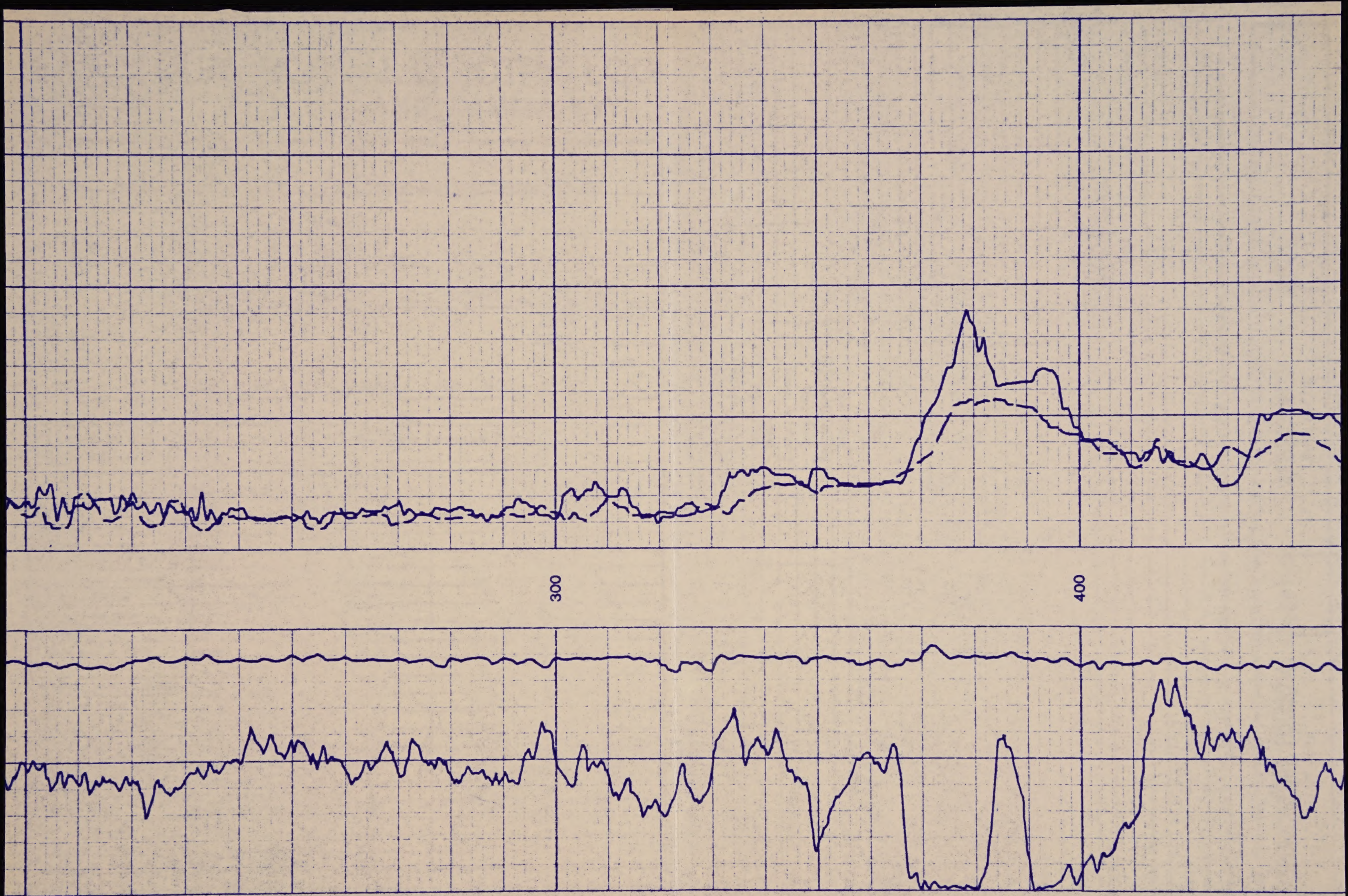
64"

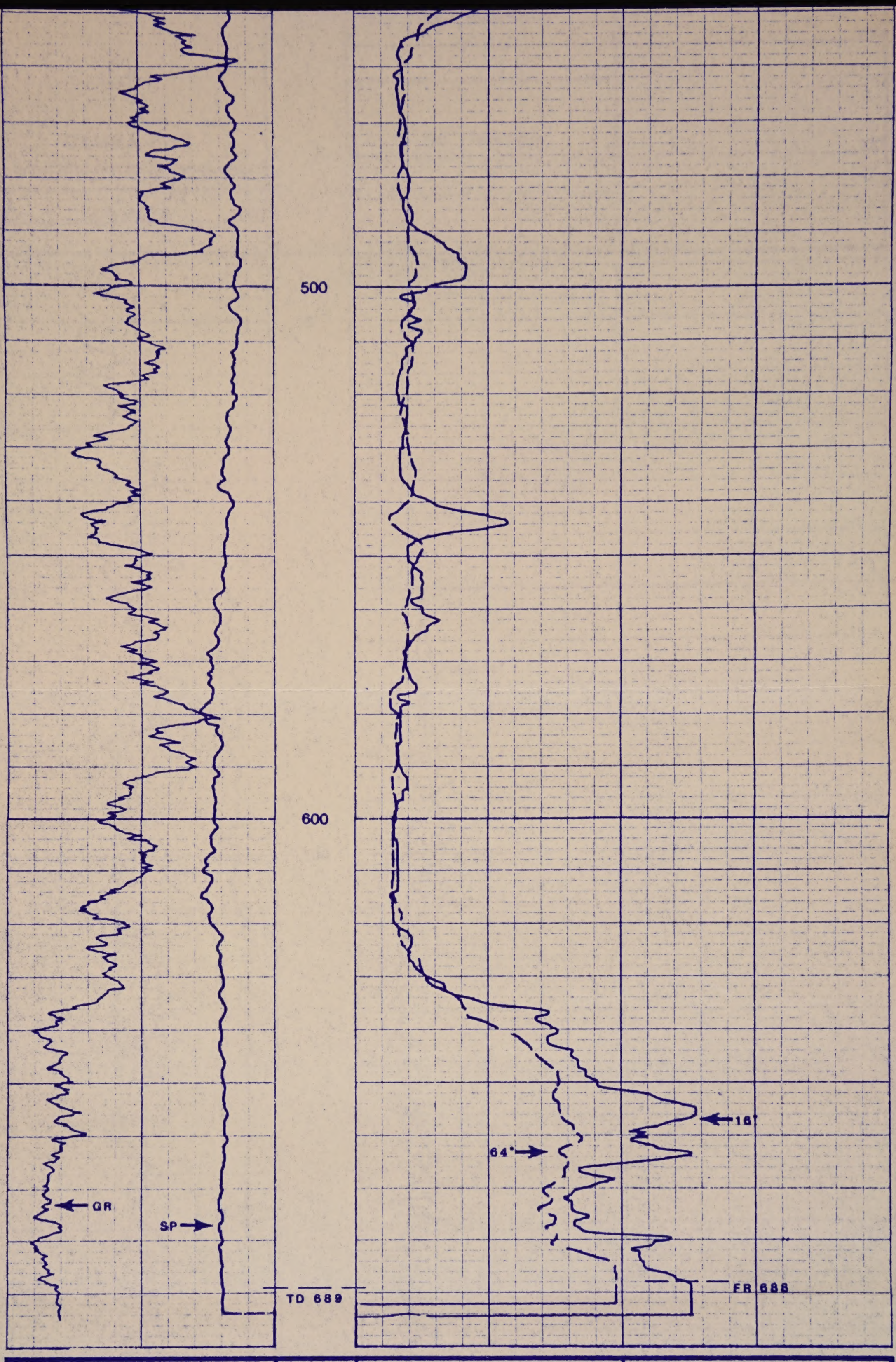
100

200






300
400



48 API UNITS 168

RADIATION INTENSITY INCREASES
GAMMA RAY

– 5 +

0 64" NORMAL 50 100

0 16" NORMAL 50 100

SPONTANEOUS POTENTIAL
Millivolts

DEPTH

RESISTIVITY
Ohms m²/m

Company	WOODWARD-CLYDE CONSULTANTS	Drillers T.D.	689
Well	MW - 6	Log F.R.	688
Field	TOANA DRAW	Log T.D.	689
County	ELKO	Elevations:	
State	NEVADA	K.B. D.F.	G.L.

BLM Library
Denver Federal Center
Bldg. 50, OC-521
P.O. Box 25047
Denver, CO 80225

TD
195
.E4
E646
1989e
v.2

88076962

STRATA DATA INC

SONIC/CALIPER LOG

FILE NO. 5110

COMPANY WOODWARD CLYDE CONSULTANTS

WELL MW - 8

FIELD TOANA DRAW

COUNTY ELKO STATE NEVADA

LOCATION:

SEC 19 TWP 42N RGE 68E

Permanent Datum GROUND LEVEL Elev.

Log Measured from G.L. Ft. Above Permanent Datum

Drilling Measured from G.L.

Other Services: DNEL/GR/SP, TEMP.LOG

Elevations: KB, DF, GL

Date	08/04/88		
Run No.	ONE		
Depth—Driller	689		
Depth—Logger	689		
Bottom Logged Interval	688		
Top Logged Interval	0		
Casing—Driller	@	@	@
Casing—Logger			
Bit Size	8"		
Type Fluid in Hole	MUD		
Density and Viscosity			
pH and Fluid Loss		cc	cc
Source of Sample	PIT		
Rm @ Meas. Temp.	5.7 @ 100 °F	@ °F	@ °F
Rmf @ Meas. Temp.	@ °F	@ °F	@ °F
Rmc @ Meas. Temp.	@ °F	@ °F	@ °F
Source of Rmf and Rmc			
Rm @ BHT	8.05 @ 70.8 °F	@ °F	@ °F
Time Since Circ.	5 HRS.		
Max. Rec. Temp. Deg. F.	70.8 °F		
Equip. No. and Location	102 ELKO		
Recorded By	MC DONALD		
Witnessed By	MERRELL		

FOLD HERE

THIS HEADING AND LOG CONFORMS TO API RECOMMENDED STANDARD PRACTICE RP-31

REMARKS

Changes in Mud Type or Additional Samples

Date / Sample No.				
Depth-Driller				
Type Fluid in Hole				
Dens. / Visc.				
pH / Fluid Loss		cc		cc
Source of Sample				
Rm @ Meas. Temp.	@ °F		@ °F	
Rmf @ Meas. Temp.	@ °F		@ °F	
Rmc @ Meas. Temp.	@ °F		@ °F	
Source Rmf / Rmc				
Rm @ BHT	@ °F		@ °F	
Rmf @ BHT	@ °F		@ °F	
Rmc @ BHT	@ °F		@ °F	

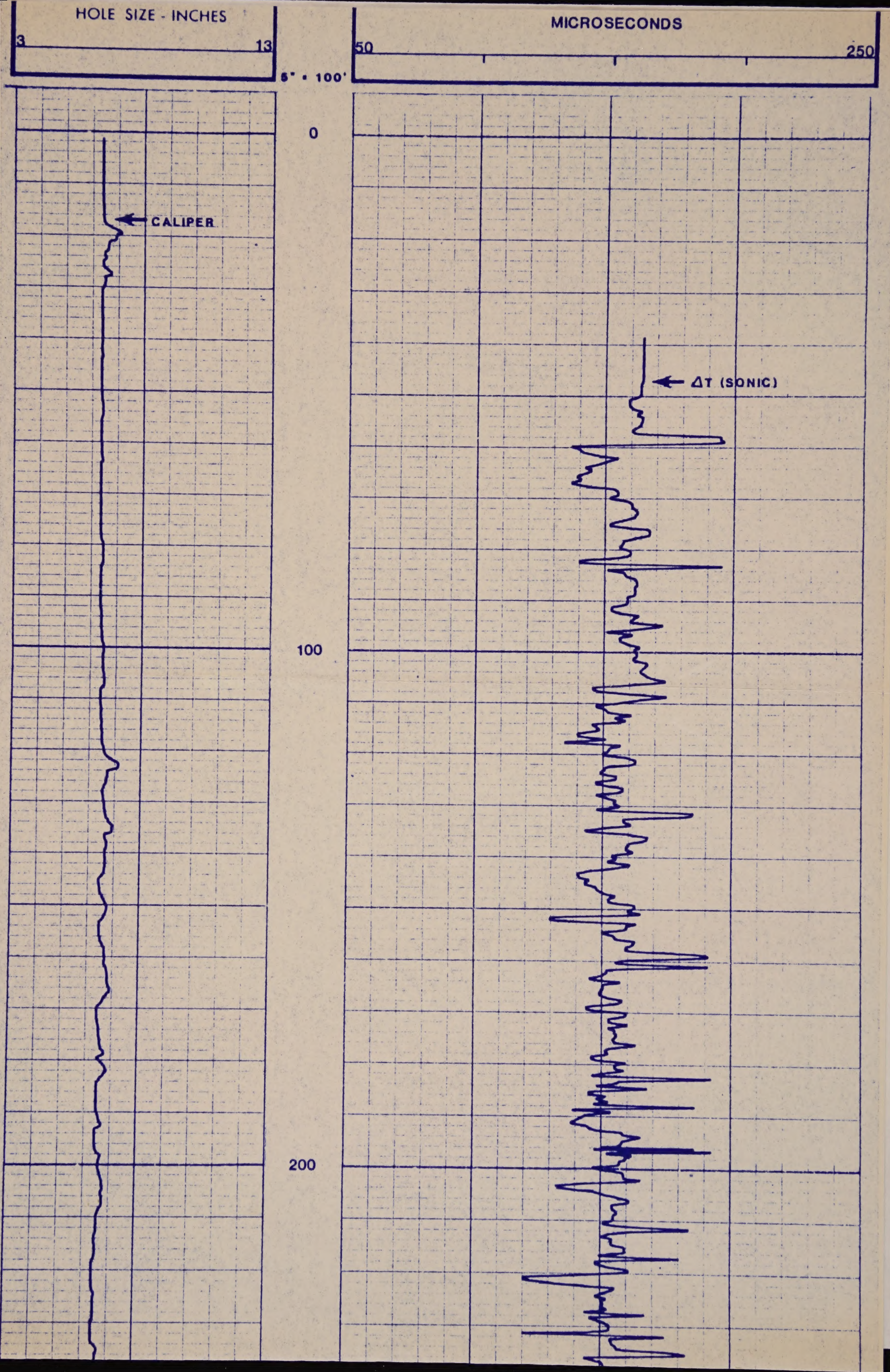
Scale Changes

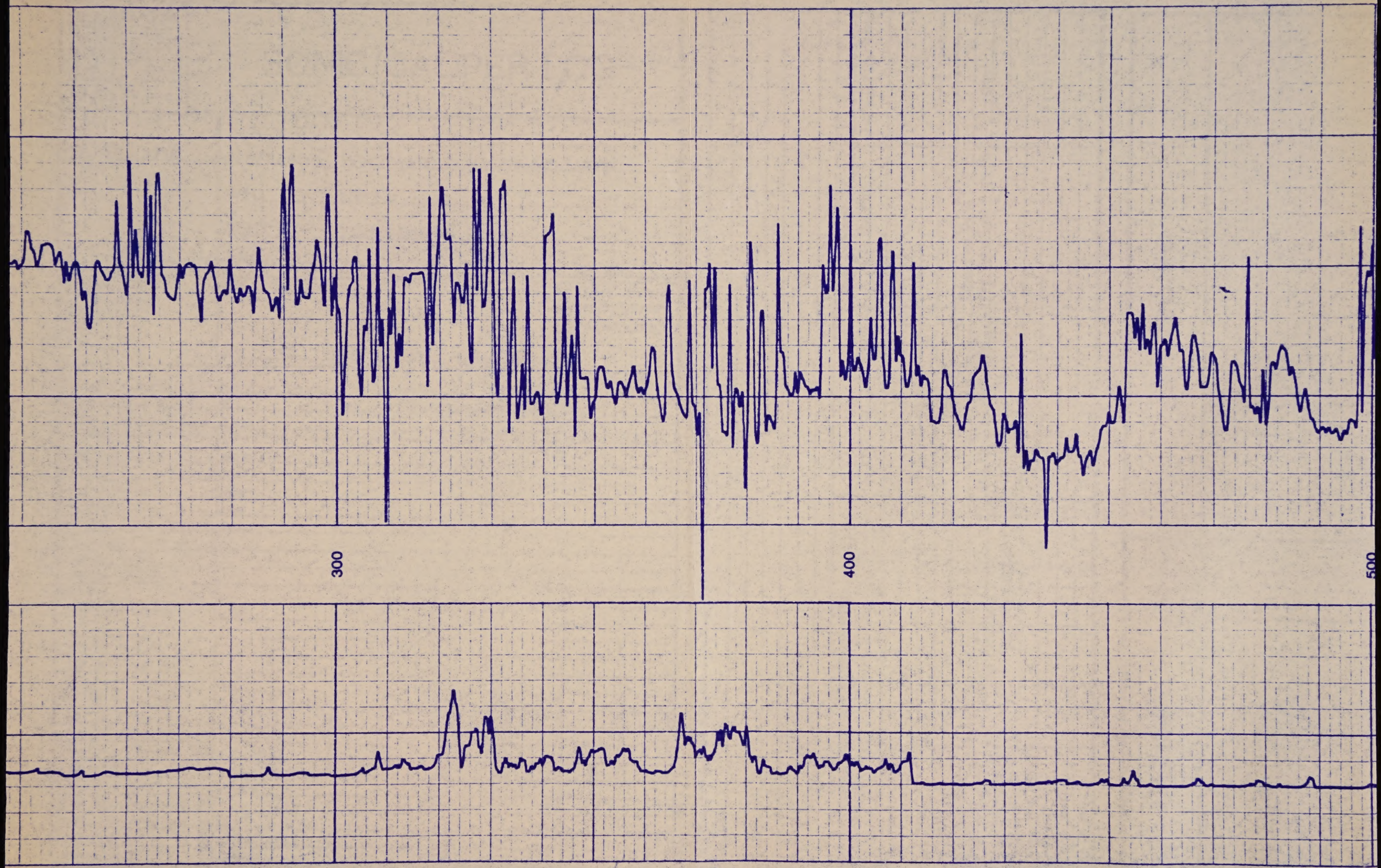
Type Log	Depth	Scale Up Hole	Scale Down Hole

Equipment Data

Run No.	Tool Type	Pad Type	Tool Position	Other

CALIPER	DEPTH	SONIC
	500	


HOLE SIZE - INCHES
3
13
5" • 100'
MICROSECONDS
50
250
0
CALIPER
ΔT (SONIC)
100
200


300
400
500

600

← CALIPER

← ΔT (SONIC)

FR 688
TD 689

3	13
HOLE SIZE - INCHES	

50	250
MICROSECONDS	

CALIPER	DEPTH	SONIC

Company WOODWARD-CLYDE CONSULTANTS
Well MW - 6
Field TOANA DRAW
County ELKO
State NEVADA

Drillers T.D. 689
Log F.R. 688
Log T.D. 689
Elevations:
K.B. D.F. G.L.

BLM Library
Denver Federal Center
Bldg. 50, OC-521
P.O. Box 25047
Denver, CO 80225

TD
195
.E4
E646
1989e
v.2
88076962

STRATA DATA INC

TEMPERATURE LOG

FILE NO 5110

COMPANY WOODWARD CLYDE CONSULTANTS

WELL MW - 6

FIELD TOANA DRAW

COUNTY ELKO STATE NEVADA

LOCATION:

SEC 19 TWP 42N RGE 66E

Other Services: DNEL/GR SONIC/CAL.

Permanent Datum GROUND LEVEL Elev

Log Measured from G.L. 0 Ft Above Permanent Datum

Drilling Measured from G.L.

Elevations: KB DF GL

Date	08/04/88			
Run No.	ONE			
Depth—Driller	689			
Depth—Logger	689			
Bottom Logged Interval	687			
Top Logged Interval	30			
Casing—Driller	@	@	@	@
Casing—Logger				
Bit Size	6"			
Type Fluid in Hole	MUD			
Density and Viscosity				
pH and Fluid Loss	cc	cc	cc	cc
Source of Sample	PIT			
Rm @ Meas. Temp.	5.7 @ 100 F	@ F	@ F	@ F
Rmf @ Meas. Temp	@ F	@ F	@ F	@ F
Rmc @ Meas. Temp.	@ F	@ F	@ F	@ F
Source of Rmf and Rmc				
Rm @ BHT	8.05 @ 70.8 F	@ F	@ F	@ F
Time Since Circ	4 HRS.			
Max. Rec. Temp. Deg. F	70.8 F	F	F	F
Equip. No. and Location	102 ELKO			
Recorded By	MC DONALD			
Witnessed By	MR. MERRELL			

FOLD HERE

THIS HEADING AND LOG CONFORMS TO API RECOMMENDED STANDARD PRACTICE RP 1

REMARKS

Changes in Mud Type or Additional Samples

Date	Sample No.	Depth-Driller	Type Fluid in Hole	Dens	Visc.	pH	Fluid Loss	Source of Sample	Rm @ Meas. Temp	Rmf @ Meas. Temp	Rmc @ Meas. Temp	Source Rmf	Rmc	Rm @ BHT	Rmf @ BHT	Rmc @ BHT
									@ F	@ F	@ F			@ F	@ F	@ F
									@ F	@ F	@ F			@ F	@ F	@ F

Scale Changes

Type Log	Depth	Scale Up Hole	Scale Down Hole

Equipment Data

Run No.	Tool Type	Pad Type	Tool Position	Other
ONE	TEMP.		FREE	COMPROBE

TEMPERATURE DEGREES F

DEPTH

TEMPERATURE INCREASES

80
70
80
5° = 100'
100
200

300

400

500

600

TD 689

FR 687

80 70 80

TEMPERATURE INCREASES

DEPTH

TEMPERATURE
DEGREES F

Company	WOODWARD CLYDE CONSULTANTS		Drillers T.D.	689	
Well	MW - 6		Log F.R.	687	
Field	TOANA DRAW		Log T.D.	689	
County	ELKO		Elevations:		
State	NEVADA		K.B.	D.F.	G.L. 8807962

BLM Library
Denver Federal Center
Bldg. 50, OC-521
P.O. Box 25047
Denver, CO 80225

TD
195
.E4
E646
1989e
v.2

STRATA DATA INC

DUAL NORMAL ELECTRIC LOG

WITH S.P. AND GAMMA RAY

FILE NO. 5105

COMPANY WOODWARD-CLYDE CONSULTANTS

WELL MW-12

FIELD TOANA DRAW

COUNTY ELKO STATE NEVADA

LOCATION:

SEC _____ TWP _____ RGE _____

Other Services
GR/SP/PT. RES
3-ARM CALIPER
TEMP. LOG
SONIC LOG

Permanent Datum GL Elev. _____
Log Measured from GL 0 Ft. Above Permanent Datum
Drilling Measured from _____

Elevations
KB _____
DF _____
GL _____

Date	07/12/88			
Run No.	ONE			
Depth—Driller	605			
Depth—Logger	601			
Bottom Logged Interval	600			
Top Logged Interval	4			
Casing—Driller	NA @	@	@	@
Casing—Logger	NA			
Bit Size	6 1/4"			
Type Fluid in Hole	MUD			
Density and Viscosity				
pH and Fluid Loss	cc	cc	cc	cc
Source of Sample				
Rm @ Meas. Temp.	@ F	@ F	@ F	@ F
Rmf @ Meas. Temp.	@ F	@ F	@ F	@ F
Rmc @ Meas. Temp.	@ F	@ F	@ F	@ F
Source of Rmf and Rmc				
Rm @ BHT	@ F	@ F	@ F	@ F
Time Since Circ.				
Max. Rec. Temp. Deg. F.	F	F	°F	°F
Equip. No. and Location	102 ELKO			
Recorded By	SPOHR			
Witnessed By	CASTELLANOS			

THIS HEADING AND LOG CONFORMS TO API RECOMMENDED STANDARD PRACTICE RP 33

FOLD HERE

Density — Equipment Data

Run No.	
Tool Model No.	
Serial No.	
Diam.	
Computer Model No.	
Serial No.	
Source Model No.	
Serial No.	

Computer Data

Gamma Ray — Equipment Data

Run No.	ONE
Tool Model No.	
Serial No.	GRS27A20
Diam.	2 1/8"
Detect. Model No.	
Type	
Length	
Dist. to Source	

General

Hoist Truck No.	102
Auxiliary Equipment	

Logging Data

Density

Run No.	T.C. Sec.	Density Scale	Correction Scale	Porosity Scale Data

Gamma Ray

Run No.	API G.R. Units Per Log Div.	Zero Div. L or R

General

Run No.	Depths From	Depths To	Speed Ft./Min.	T.C. Sec.	Sens. Settings
1	600	4	20	3	500

Reference Literature:

Remarks:

RESISTIVITY
Ohms m^2/m

SPONTANEOUS POTENTIAL
Millivolts

DEPTH

2

GAMMA RAY

RADIATION INTENSITY INCREASES

24 API UNITS 148

5" • 100'

16" NORMAL

0 50 100

64" NORMAL

0 50 100

GR

SP

0

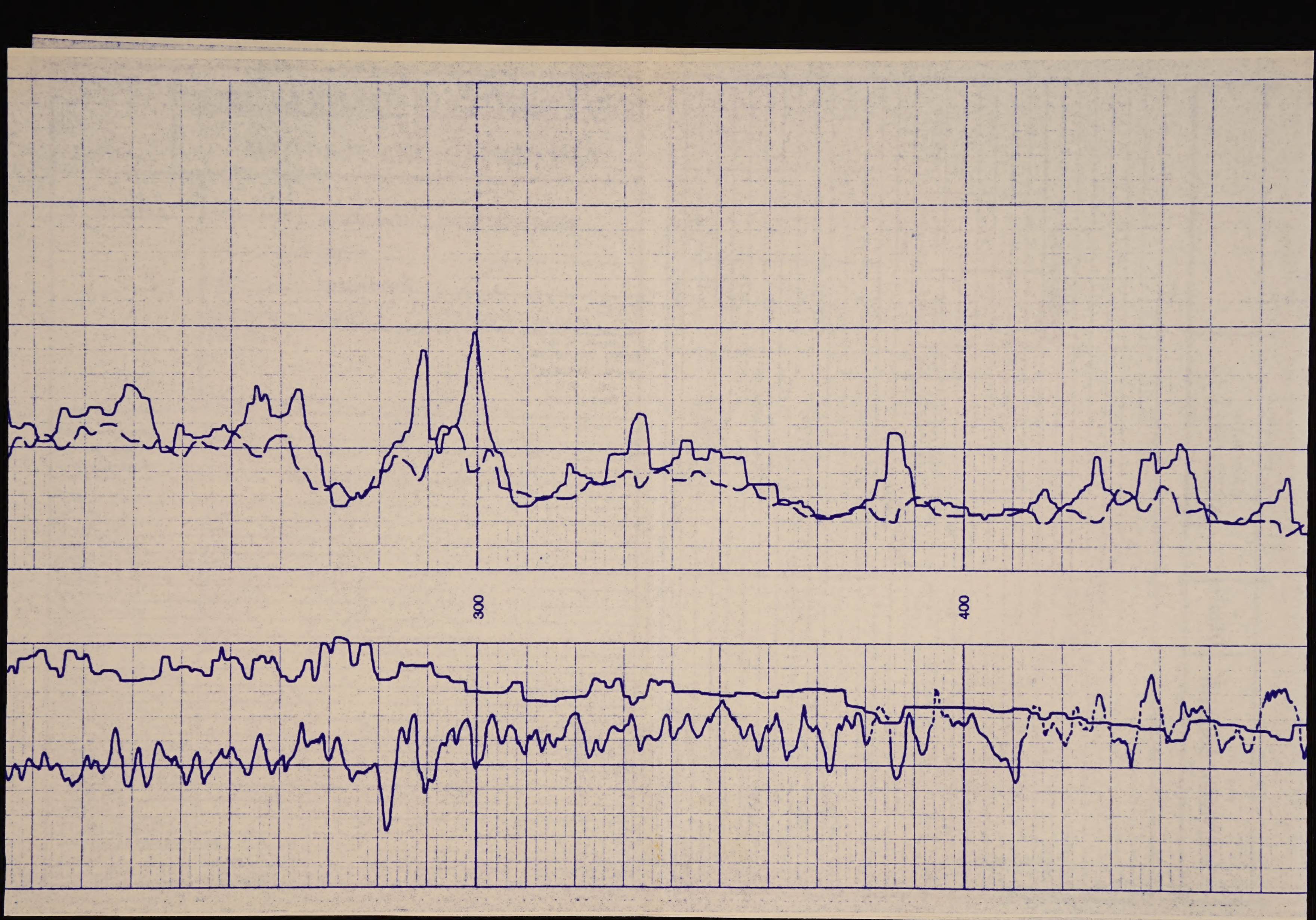
100

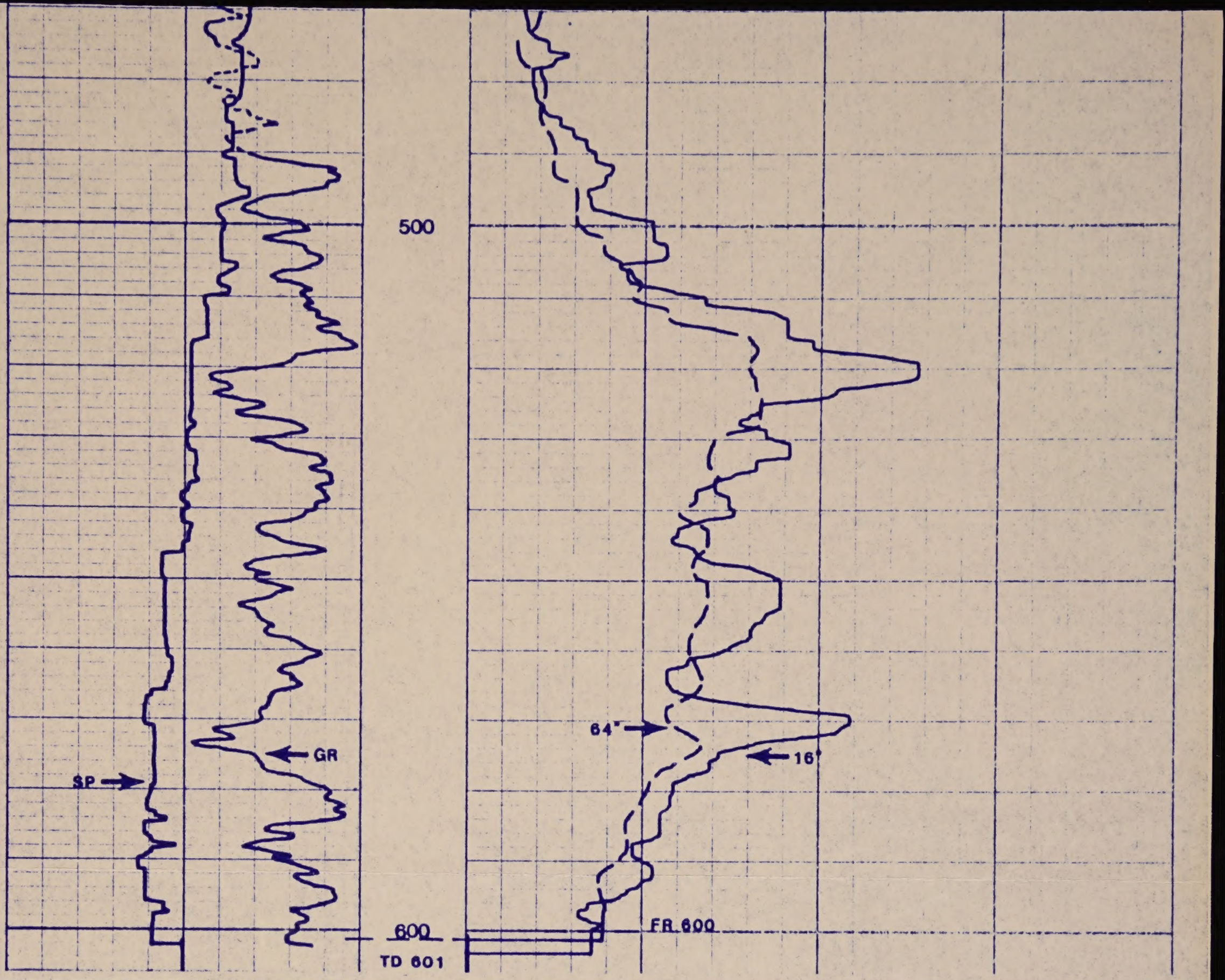
200

FLUID LEVEL

64"

16"


300
400



24 API UNITS 148		0 64" NORMAL 50 100
RADIATION INTENSITY INCREASES GAMMA RAY		0 16" NORMAL 50 100
− 2 +		
SPONTANEOUS POTENTIAL Millivolts	DEPTH	RESISTIVITY Ohms m²/m

Company	WOODWARD-CLYDE CONSULTANTS	Drillers T.D.	605
Well	MW-12	Log F.R.	600
Field	TOANA DRAW	Log T.D.	601
County	ELKO	Elevations:	
State	NEVADA	K.B. D.F.	G.L.

BLM Library
Denver Federal Center
Bldg. 50, OC-521
P.O. Box 25047
Denver, CO 80225

TD
195
.E4
E646
1989e
v.2
88076962

STRATA DATA INC

SONIC/CALIPER LOG

FILE NO. 5105

COMPANY WOODWARD-CLYDE CONSULTANTS

WELL MW-12

FIELD TOANA DRAW

COUNTY ELKO STATE NEVADA

LOCATION:

SEC ____ TWP ____ RGE ____

Other Services
GR/SP/DNEL
SINGLE PT. RES.
3-ARM CALIPER
TEMP.

Permanent Datum GL Elev. ____
Log Measured from GL 0 Ft. Above Permanent Datum
Drilling Measured from ____

Elevations:
KB ____
DF ____
GL ____

Date	07/12/89			
Run No.	ONE			
Depth—Driller	605			
Depth—Logger	601			
Bottom Logged Interval	600			
Top Logged Interval	4			
Casing—Driller	NA @	@	@	@
Casing—Logger	NA			
Bit Size	6 1/4"			
Type Fluid in Hole	MUD			
Density and Viscosity				
pH and Fluid Loss	cc	cc	cc	cc
Source of Sample				
Rm @ Meas. Temp.	@ °F	@ °F	@ °F	@ °F
Rmf @ Meas. Temp.	@ °F	@ °F	@ °F	@ °F
Rmc @ Meas. Temp.	@ °F	@ °F	@ °F	@ °F
Source of Rmf and Rmc				
Rm @ BHT	@ °F	@ °F	@ °F	@ °F
Time Since Circ.				
Max. Rec. Temp. Deg. F.	73.2°F	°F	°F	°F
Equip. No. and Location	102 ELKO			
Recorded By	SPOHR			
Witnessed By	CASTELLANOS			

FOLD HERE

THIS HEADING AND LOG CONFORMS TO API RECOMMENDED STANDARD PRACTICE RP-31

REMARKS

Scale Changes

	Scale Up Hole	Scale Down Hole
Type Log		
Depth		

Equipment Data

	Tool Type	Pad Type	Tool Position	Other
Run No.				

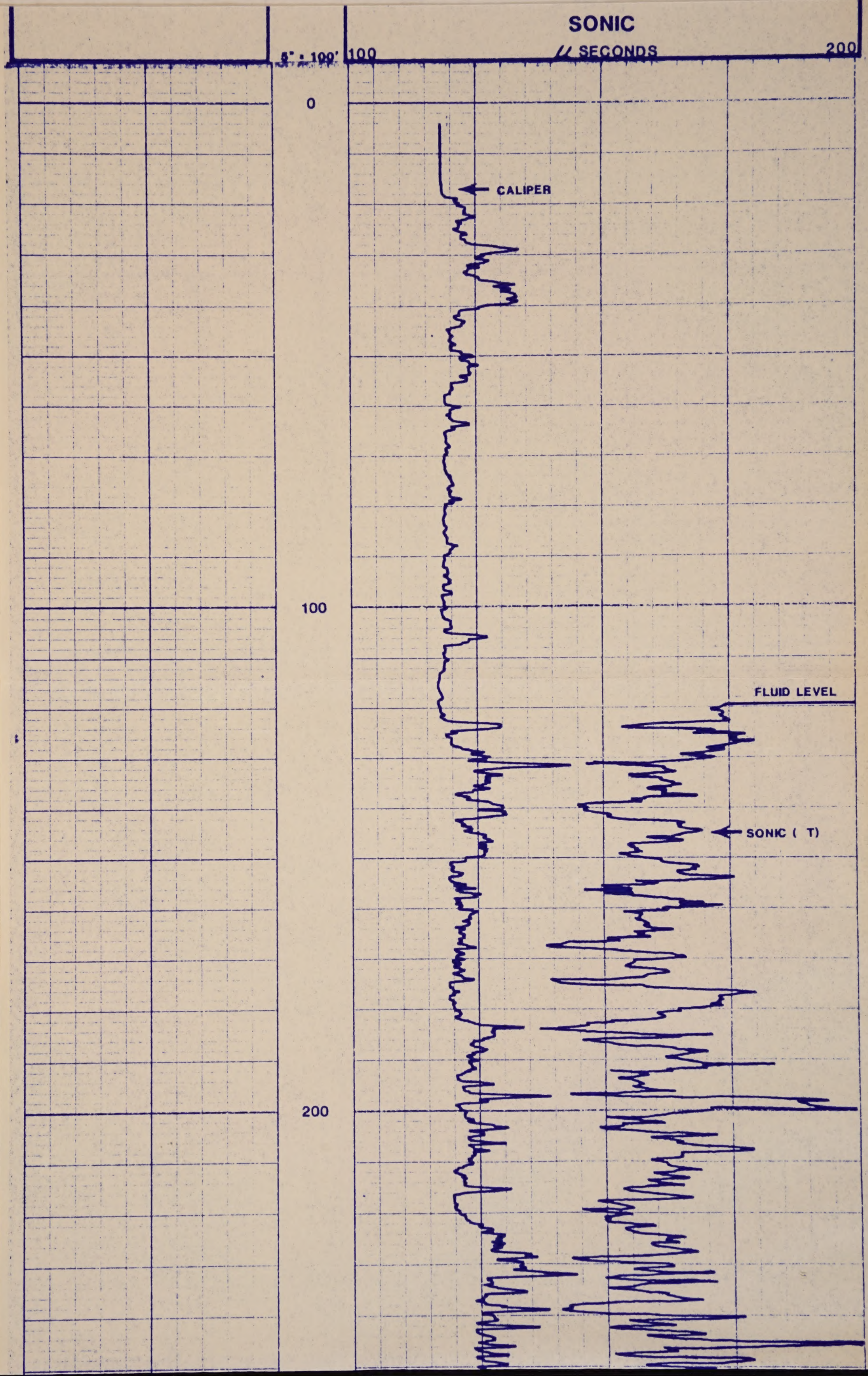
Changes in Mud Type or Additional Samples

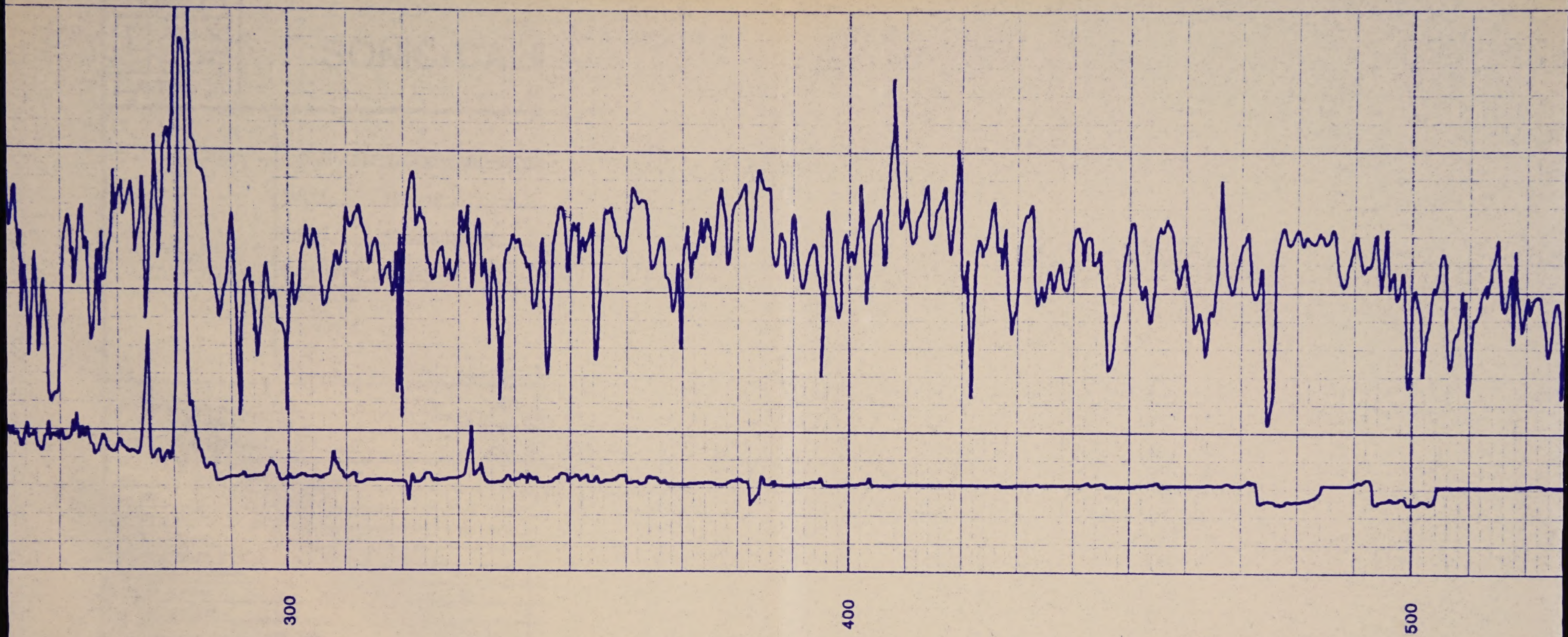
Date									
Sample No.									
Depth-Driller									
Type Fluid in Hole									
Dens. / Visc.	/	/	/	/	/	/	/	/	/
pH / Fluid Loss	/ cc	/ cc	/ cc	/ cc	/ cc	/ cc	/ cc	/ cc	/ cc
Source of Sample									
Rm @ Meas. Temp.	@ °F	@ °F	@ °F	@ °F	@ °F	@ °F	@ °F	@ °F	@ °F
Rmf @ Meas. Temp.	@ °F	@ °F	@ °F	@ °F	@ °F	@ °F	@ °F	@ °F	@ °F
Rmc @ Meas. Temp.	@ °F	@ °F	@ °F	@ °F	@ °F	@ °F	@ °F	@ °F	@ °F
Source Rmf / Rmc	/	/	/	/	/	/	/	/	/
Rm @ BHT	@ °F	@ °F	@ °F	@ °F	@ °F	@ °F	@ °F	@ °F	@ °F
Rmf @ BHT	@ °F	@ °F	@ °F	@ °F	@ °F	@ °F	@ °F	@ °F	@ °F
Rmc @ BHT	@ °F	@ °F	@ °F	@ °F	@ °F	@ °F	@ °F	@ °F	@ °F

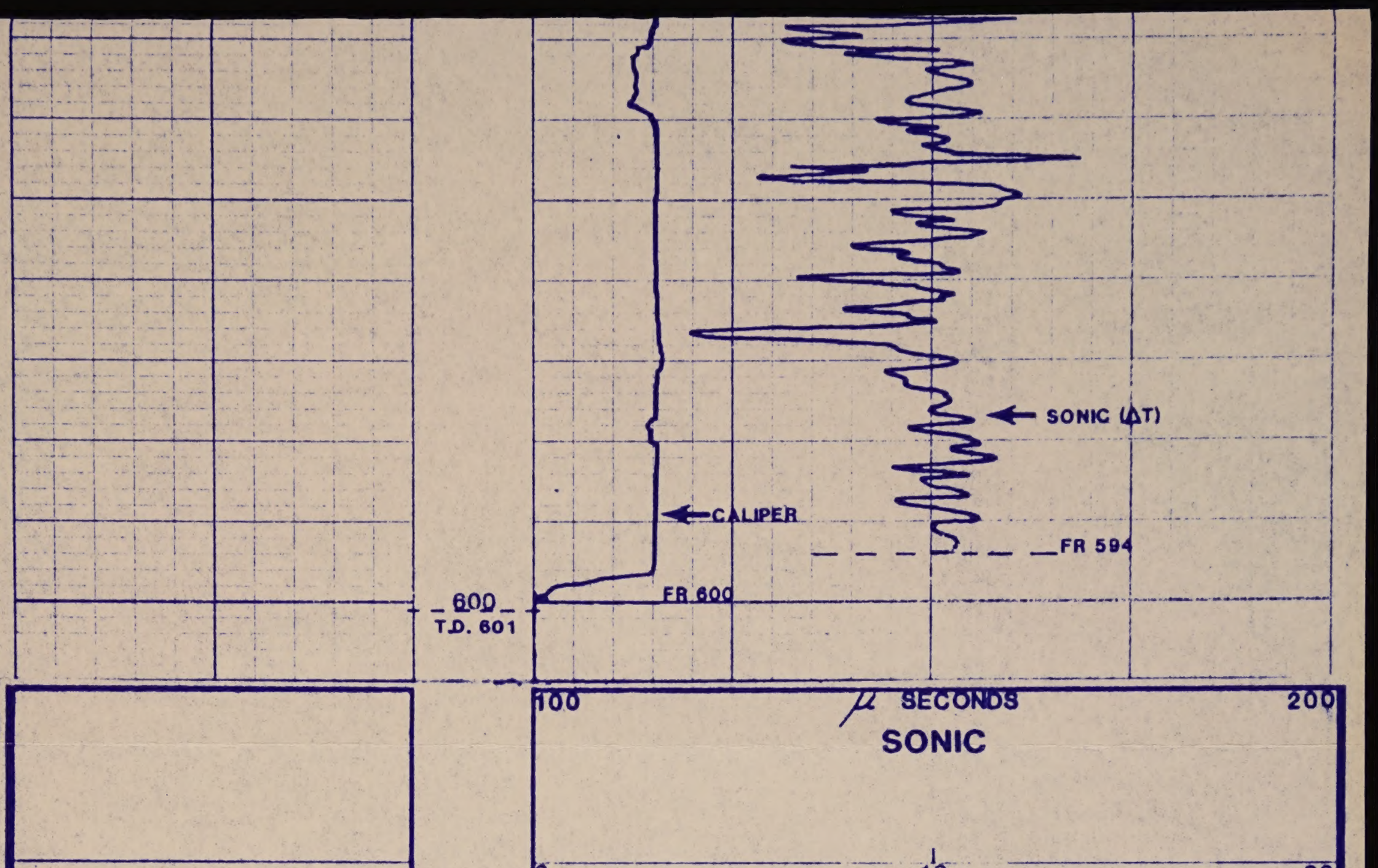
CALIPER

HOLE DIAMETER
INCHES
23
13

DEPTH
3


SONIC
5" : 100'
100
SECONDS
200
0
CALIPER
100
FLUID LEVEL
SONIC (T)
200


300
400
500



Company	WOODWARD-CLYDE CONSULTANTS	Drillers T.D	605	
Well	MW-12	Log F.R.	600	
Field	TOANA DRAW	Log T.D.	601	
County	ELKO	Elevations:		
State	NEVADA	K.B.	D.F.	G.L.

BLM Library
Denver Federal Center
Bldg. 50, OC-521
P.O. Box 25047
Denver, CO 80225

TD
195
.E4
E646
1989e
v.2

88076962

STRATA DATA INC

TEMPERATURE LOG
WITH DIFFERENTIAL TEMPERATURE

FILE NO 5105

COMPANY WOODWARD-CLYDE CONSULTANTS

WELL MW-12

FIELD TOANA DRAW

COUNTY ELKO STATE NEVADA

LOCATION:

SEC _____ TWP _____ RGE _____

Other Services
GR/SP/PT. RES.
DNEL
CALIPER
SONIC

Permanent Datum GL Elev _____
Log Measured from GL 0 Ft Above Permanent Datum
Drilling Measured from _____

Elevations
KB _____
DF _____
GL _____

Date	07/12/88			
Run No.	ONE			
Depth—Driller	605			
Depth—Logger	601			
Bottom Logged Interval	601			
Top Logged Interval	100			
Casing—Driller	NA @	@	@	@
Casing—Logger	NA			
Bit Size	6 1/4"			
Type Fluid in Hole	MUD			
Density and Viscosity				
pH and Fluid Loss	cc	cc	cc	cc
Source of Sample				
Rm @ Meas. Temp	10.8 @ 68 °F	@ °F	@ °F	@ °F
Rmf @ Meas. Temp	@ °F	@ °F	@ °F	@ °F
Rmc @ Meas. Temp.	@ °F	@ °F	@ °F	@ °F
Source of Rmf and Rmc				
Rm @ BHT	@ °F	@ °F	@ °F	@ °F
Time Since Circ.				
Max. Rec. Temp. Deg. F.	73.2°F	°F	°F	°F
Equip. No. and Location	102 ELKO			
Recorded By	SPOHR			
Witnessed By	COSTELLANOS			

FOLD HERE

THIS HEADING AND LOG CONFORMS TO API RECOMMENDED STANDARD PRACTICE RP-31

REMARKS

Scale Changes

	Scale Up Hole	Scale Down Hole
Depth		
Type Log		

Equipment Data

	Tool Type	Pad Type	Tool Position	Other
	TEMP.	NA	FREE	COMPROBE

Changes in Mud Type or Additional Samples

Date	Sample No.		
Depth-Driller			
Type Fluid in Hole			
Dens.	Visc.		
pH	Fluid Loss	cc	cc
Source of Sample			
Rm @ Meas. Temp	@ °F	@ °F	@ °F
Rmf @ Meas. Temp.	@ °F	@ °F	@ °F
Rmc @ Meas. Temp.	@ °F	@ °F	@ °F
Source Rmf	Rmc		
Rm @ BHT	@ °F	@ °F	@ °F
Rmf @ BHT	@ °F	@ °F	@ °F
Rmc @ BHT	@ °F	@ °F	@ °F

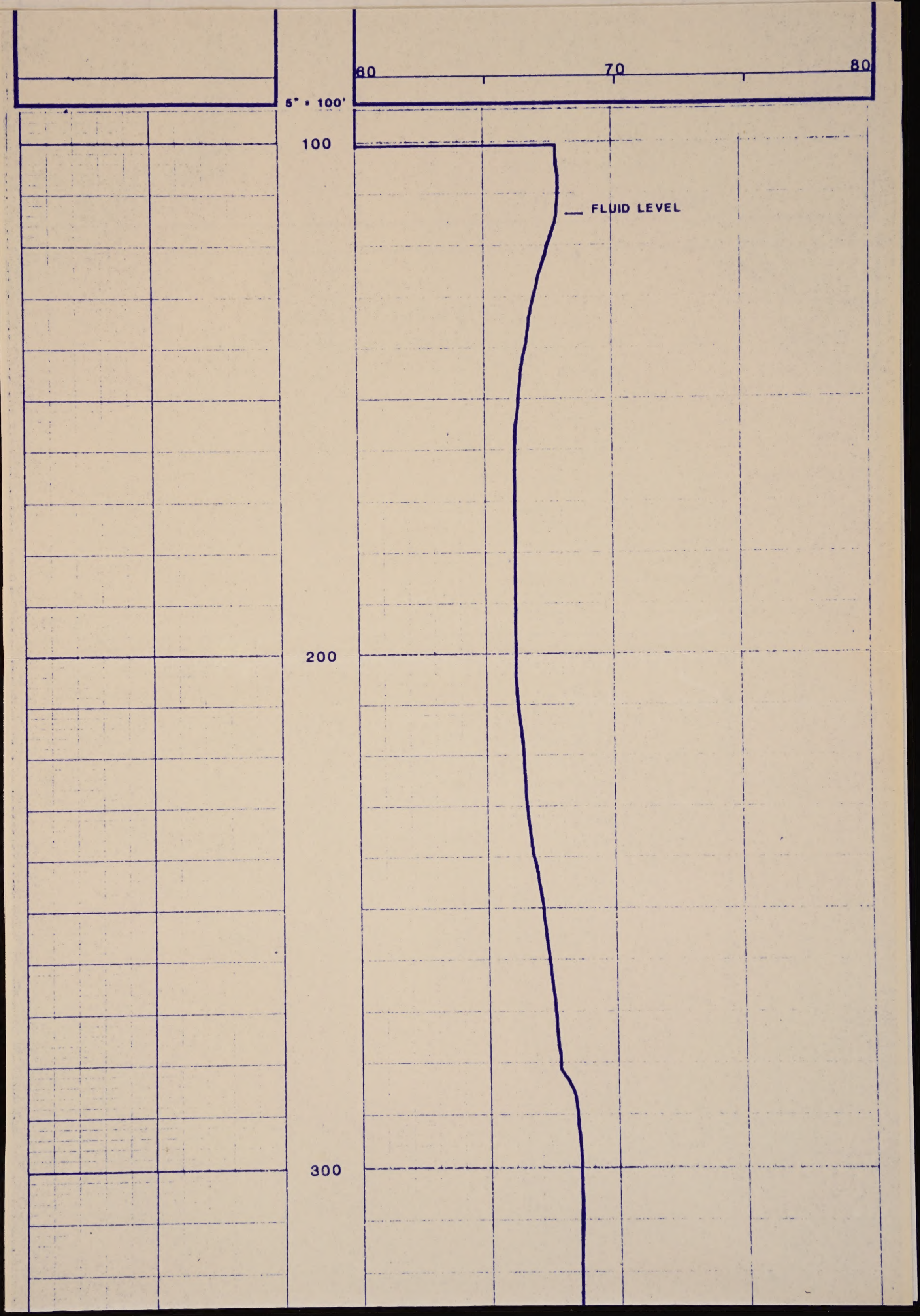
Run No.		
ONE		

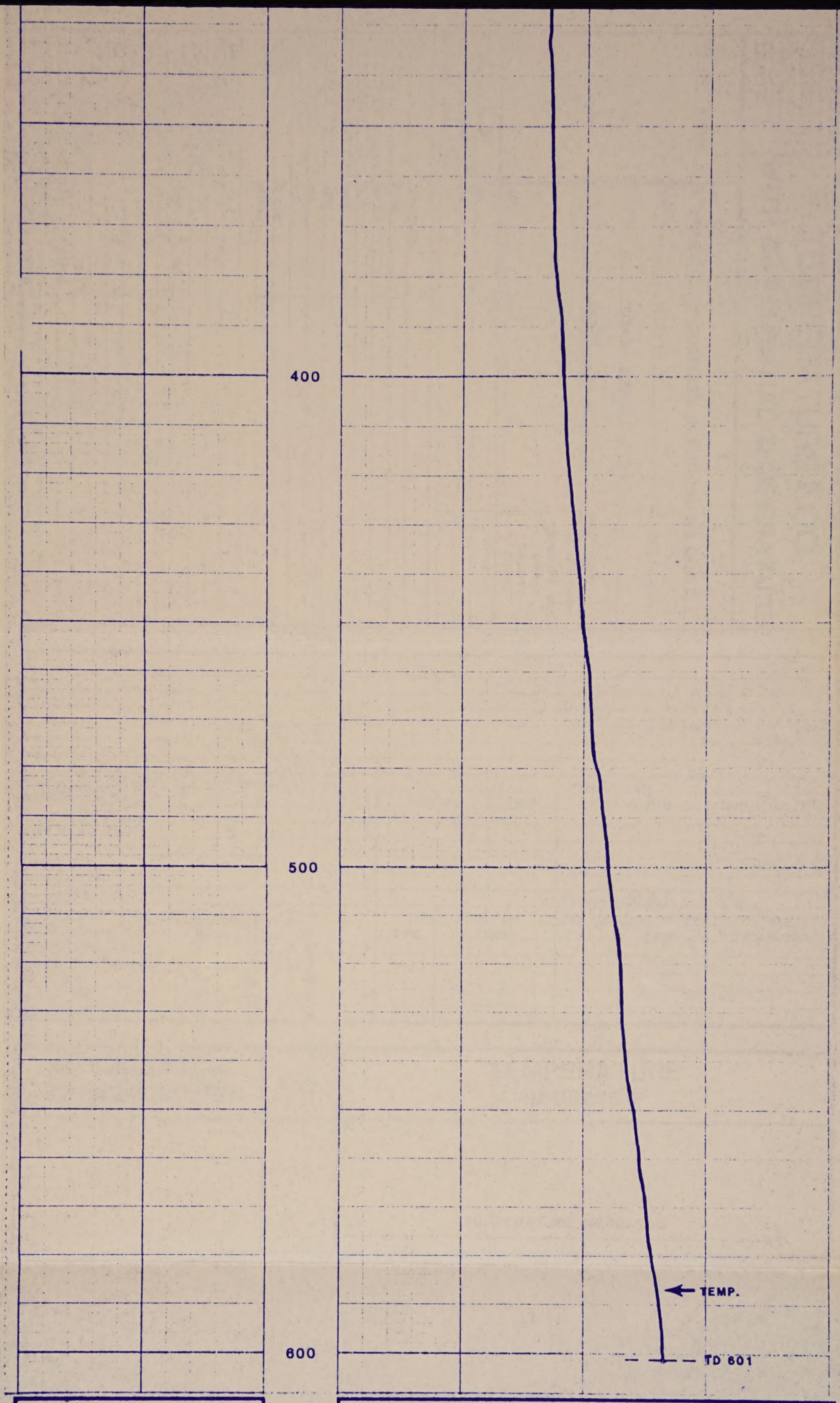
TEMPERATURE
DEGREES F

TEMPERATURE INCREASES

DEPTH

DIFFERENTIAL TEMPERATURE


60
70
80
5" = 100'
100
FLUID LEVEL
200
300



60 70 80

TEMPERATURE INCREASES

DIFFERENTIAL TEMPERATURE

DEPTH

TEMPERATURE
DEGREES F

Company	WOODWARD-CLYDE CONSULTANTS	Drillers T.D.	605	
Well	MW-12	Log F.R.	601	
Field	TOANA DRAW	Log T.D.	601	
County	ELKO	Elevations:		
State	NEVADA	K.B.	D.F.	G.L.

BLM Library
Denver Federal Center
Bldg. 50, OC-521
P.O. Box 25047
Denver, CO 80225

TD
195
.E4
E646
1989e
v.2

88076962

STRATA DATA INC.

DUAL NORMAL ELECTRIC LOG WITH S.P. AND GAMMA RAY

FILE NO. 5113

COMPANY WOODWARD-CLYDE CONSULTANTS

WELL TW - 14

FIELD TOANA DRAW

COUNTY ELKO STATE NEVADA

LOCATION:

SEC. TWP. RGE.

Permanent Datum GROUND LEVEL Elev.

Log Measured from G.L. Ft. Above Permanent Datum

Drilling Measured from G.L.

Date	8/31/88		
Run No.	ONE		
Depth—Driller	500		
Depth—Logger	506		
Bottom Logged Interval	507		
Top Logged Interval	2		
Casing—Driller	NONE @	@	@
Casing—Logger	N/A		
Bit Size	8 7/8"		
Type Fluid in Hole	FORMATION WATER		
Density and Viscosity			
pH and Fluid Loss	cc	cc	cc
Source of Sample			
Rm @ Meas. Temp.	@ °F	@ °F	@ °F
Rmf @ Meas. Temp.	@ °F	@ °F	@ °F
Rmc @ Meas. Temp.	@ °F	@ °F	@ °F
Source of Rmf and Rmc			
Rm @ BHT	@ °F	@ °F	@ °F
Time Since Circ.			
Max. Rec. Temp. Deg. F.	70.8 °F	°F	°F
Equip. No. and Location	102 ELKO		
Recorded By	MC DONALD		
Witnessed By	MR. MERRELL		

Other Services: SONIC/CAL. TEMP.

Elevations: KB DF GL

FOLD HERE

THIS HEADING AND LOG CONFORMS TO API RECOMMENDED STANDARD PRACTICE RP 31

Gamma Ray — Equipment Data				Density — Equipment Data			
Run No.	ONE			Run No.			
Tool Model No.				Tool Model No.			
Serial No.	GRS27A20			Serial No.			
Diam.	1 3/4"			Diam.			
Detect. Model No.	S-4			Computer Model No.			
Type	SCINT,			Serial No.			
Length	4"			Source Model No.			
Dist. to Source	N/A			Serial No.			
General				Computer Data			
Hoist Truck No.	102						
Auxiliary Equipment							

Logging Data

General				Gamma Ray				Density			
Run No.	Depths From	Depths To	Speed Ft./Min.	T.C. Sec.	Sens. Settings	Zero Div. L or R	API G.R. Units Per Log Div.	T.C. Sec.	Density Scale	Correction Scale	Porosity Scale Data
1	2	507	20	3	140	2L	16				

Remarks: FLUID LEVEL APPROX. 316'.
HYDRAULIC OIL FROM RIG WAS FLOATING ON TOP OF WATER.

Reference Literature:

SPONTANEOUS POTENTIAL Millivolts	DEPTH	RESISTIVITY Ohms m^2/m	

10

GAMMA RAY

RADIATION INTENSITY INCREASES

32 API UNITS 192

5" = 100'

16" NORMAL

0 50 100

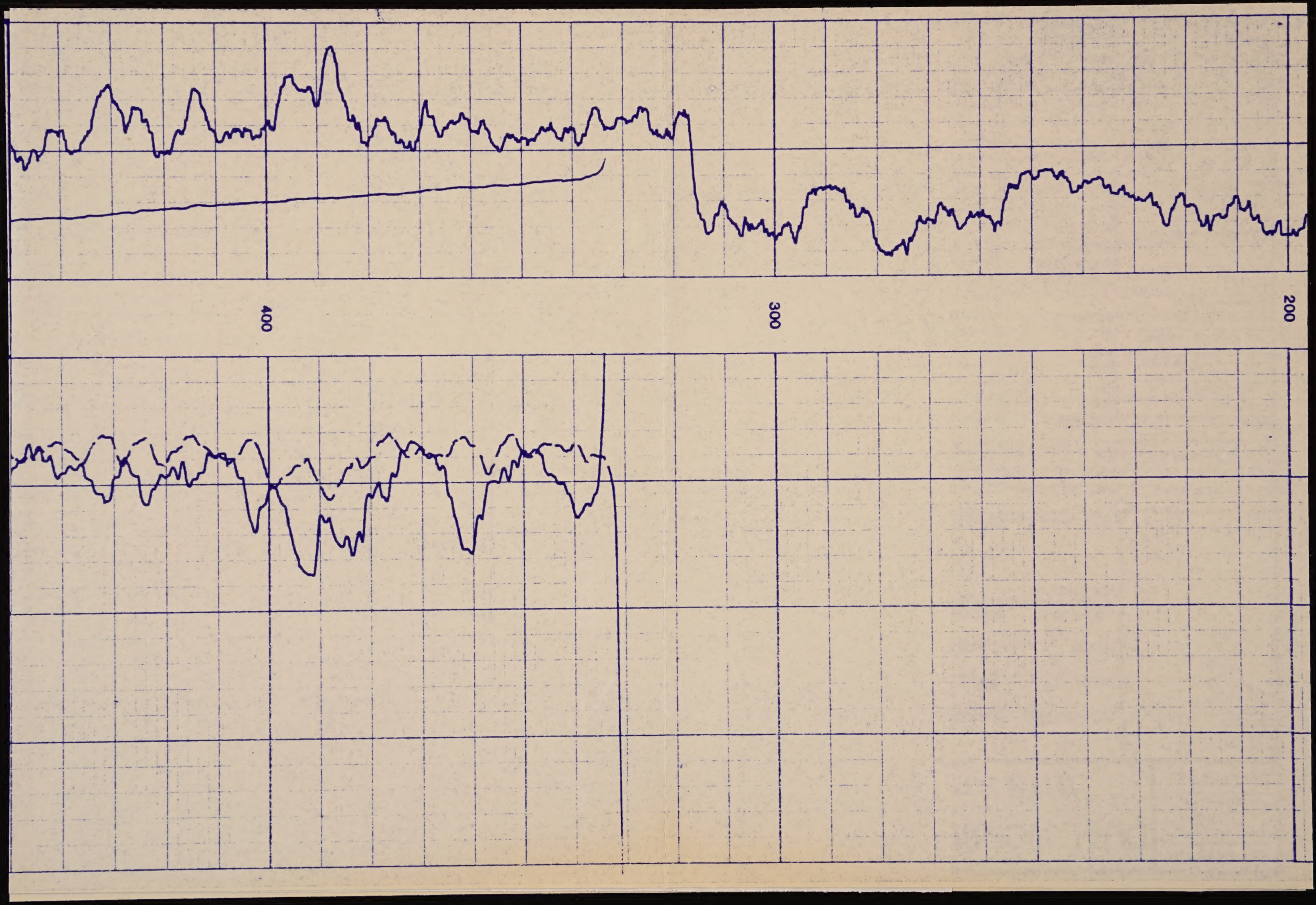
64" NORMAL

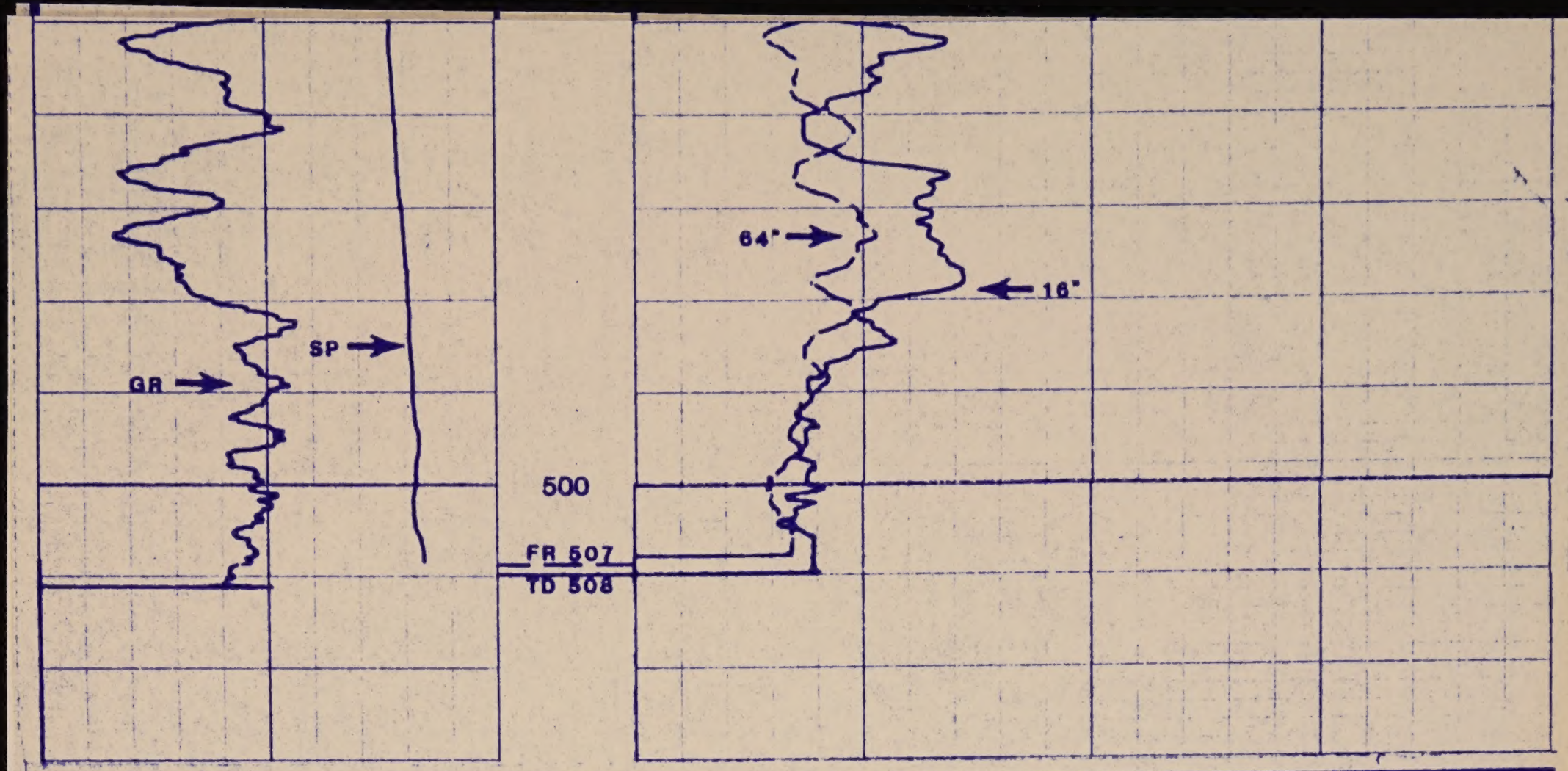
0 50 100

GR

0

100


400
300
200



32 API UNITS 192

RADIATION INTENSITY INCREASES
GAMMA RAY

\- |↔| +

0 64" NORMAL 50 100

0 16" NORMAL 50 100

SPONTANEOUS POTENTIAL Millivolts	DEPTH	RESISTIVITY Ohms m²/m	

Company	WOODWARD–CLYDE CONSULTANTS		Drillers T.D.	600	
Well	TW – 14		Log F.R.	507	
Field	TOANA DRAW		Log T.D.	508	
County	ELKO		Elevations:		
State	NEVADA		K.B.	D.F.	G.L.

BLM Library
Denver Federal Center
Bldg. 50, OC-521
P.O. Box 25047
Denver, CO 80225

TD
195
.E4
E646
1989e
v.2
88076962

STRATA DATA INC

CALIPER LOG

FILE NO. 5113

COMPANY WOODWARD-CLYDE CONSULTANTS

WELL TW - 14

FIELD TOANA DRAW

COUNTY ELKO STATE NEVADA

LOCATION:

SEC ____ TWP ____ RGE ____

Other Services
DNEL/GR
TEMP.

Permanent Datum GROUND LEVEL Elev. ____
Log Measured from GL ____ Ft. Above Permanent Datum
Drilling Measured from GL

Elevations:
KB ____
DF ____
GL ____

Date	8/31/88			
Run No.	ONE			
Depth—Driller	600			
Depth—Logger	508			
Bottom Logged Interval	508			
Top Logged Interval	4			
Casing—Driller	NONE @	@	@	@
Casing—Logger	N/A			
Bit Size	9 7/8"			
Type Fluid in Hole	FORMATION WATER			
Density and Viscosity				
pH and Fluid Loss	cc	cc	cc	cc
Source of Sample				
Rm @ Meas. Temp.	@ °F	@ °F	@ °F	@ °F
Rmf @ Meas. Temp.	@ °F	@ °F	@ °F	@ °F
Rmc @ Meas. Temp.	@ °F	@ °F	@ °F	@ °F
Source of Rmf and Rmc				
Rm @ BHT	@ °F	@ °F	@ °F	@ °F
Time Since Circ.				
Max. Rec. Temp. Deg. F.	70.8°F	°F	°F	°F
Equip. No. and Location	102 ELKO			
Recorded By	MC DONALD			
Witnessed By	MR. MERRELL			

FOLD HERE

THIS HEADING AND LOG CONFORMS TO API RECOMMENDED STANDARD PRACTICE RP-31

REMARKS

Scale Changes: Type Log | Depth | Scale Up Hole | Scale Down Hole

Equipment Data: Tool Type | Pad Type | Tool Position | Other
4-ARM CAL. | | CENT. | COMP.

Changes in Mud Type or Additional Samples: Date | Sample No. | Run No.
Depth-Driller
Type Fluid in Hole
Dens. | Visc.
pH | Fluid Loss cc
Source of Sample
Rm @ Meas. Temp. @ °F
Rmf @ Meas. Temp. @ °F
Rmc @ Meas. Temp. @ °F
Source Rmf | Rmc
Rm @ BHT @ °F
Rmf @ BHT @ °F
Rmc @ BHT @ °F

ONE

CALIPER | DEPTH

HOLE SIZE - INCHES

8 18

5" = 100'

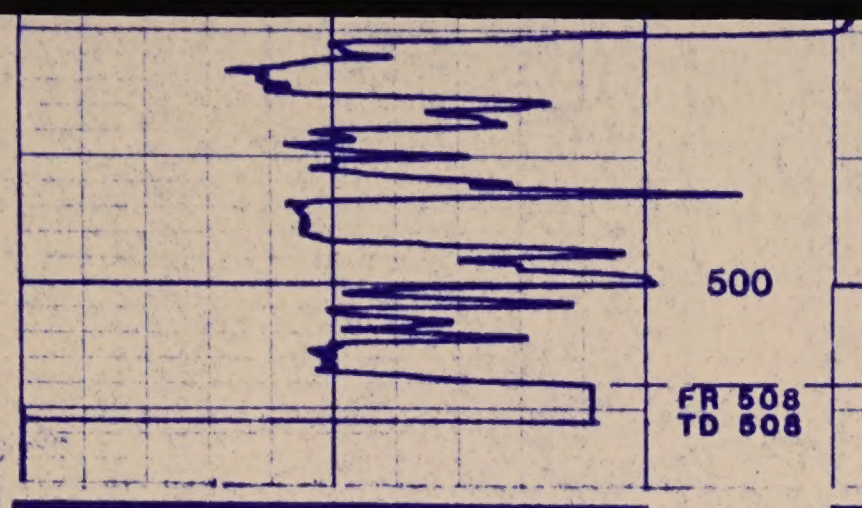
0

100

200

300

400



8 18

HOLE SIZE - INCHES

CALIPER

DEPTH

Company	WOODWARD-CLYDE CONSULTANTS		Drillers T.D.	600	
Well	TW - 14		Log F.R.	508	
Field	TOANA DRAW		Log T.D.	508	
County	ELKO		Elevations:		
State	NEVADA		K.B.	D.F.	G.L.

BLM Library
Denver Federal Center
Bldg. 50, OC-521
P.O. Box 25047
Denver, CO 80225

TD
195
.E4
E646
1989e
v.2
88076962

STRATA DATA INC

TEMPERATURE LOG

FILE NO 5113

COMPANY WOODWARD-CLYDE CONSULTANTS

WELL TW - 14

FIELD TOANA DRAW

COUNTY ELKO STATE NEVADA

LOCATION:

SEC ____ TWP ____ RGE ____

Other Services
DNEL/GR
CALIPER

Permanent Datum GROUND LEVEL Elev ____
Log Measured from G.L. ____ Ft. Above Permanent Datum
Drilling Measured from G.L.

Elevations
KB ____
DF ____
GL ____

Date	8/31/88							
Run No.	ONE							
Depth—Driller	800							
Depth—Logger	508							
Bottom Logged Interval	508							
Top Logged Interval	280							
Casing—Driller	NONE	@		@		@		
Casing—Logger								
Bit Size	9 7/8							
Type Fluid in Hole	FORMATION WATER							
Density and Viscosity								
pH and Fluid Loss		cc		cc		cc		cc
Source of Sample								
Rm @ Meas. Temp.		@ F		@ F		@ F		@ F
Rmf @ Meas. Temp		@ F		@ F		@ F		@ F
Rmc @ Meas. Temp		@ F		@ F		@ F		@ F
Source of Rmf and Rmc								
Rm @ BHT		@ F		@ F		@ F		@ F
Time Since Circ								
Max Rec. Temp Deg. F	70.8 F			F		F		F
Equip. No and Location	102 ELKO							
Recorded By	MC DONALD							
Witnessed By	MR. MERRELL							

FOLD HERE

THIS HEADING AND LOG CONFORMS TO API RECOMMENDED STANDARD PRACTICE RP 31

REMARKS FLUID LEVEL APPROX. 315'.

Scale Changes

Type Log	Depth	Scale Up Hole	Scale Down Hole

Equipment Data

Tool Type	Pad Type	Tool Position	Other
TEMP.		FREE	COMP.

Changes in Mud Type or Additional Samples

Date	Sample No.																							
Depth-Driller																								
Type Fluid in Hole																								
Dens.	Visc.																							
pH	Fluid Loss	cc																						
Source of Sample																								
Rm @ Meas. Temp		@ F																						
Rmf @ Meas. Temp		@ F																						
Rmc @ Meas. Temp		@ F																						
Source Rmf Rmc																								
Rm @ BHT		@ F																						
Rmf @ BHT		@ F																						
Rmc @ BHT		@ F																						

Run No.																								
	ONE																							

TEMPERATURE
DEGREES F

TEMPERATURE INCREASES

DEPTH

70

90

5" = 100'

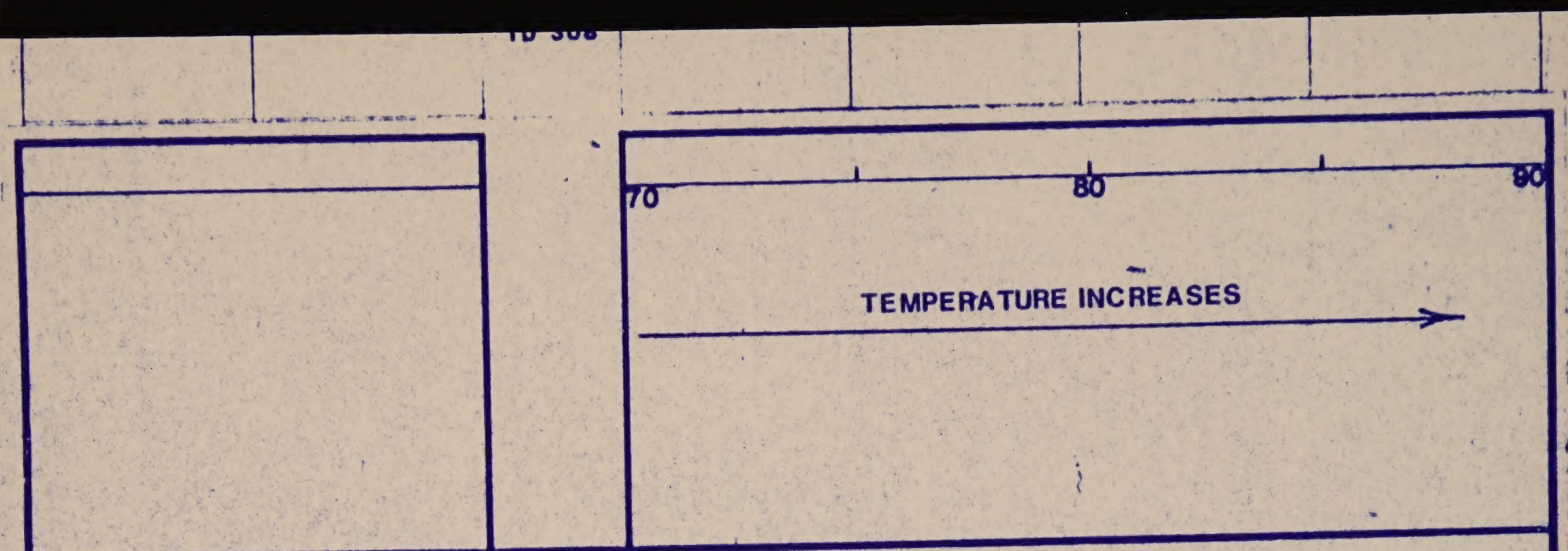
300

FLUID LEVEL

400

500

ER 308



Company	WOODWARD-CLYDE CONSULTANTS	Drillers T.D.	600
Well	TW - 14	Log F.R.	508
Field	TOANA DRAW	Log T.D.	508
County	ELKO	Elevations:	
State	NEVADA	K.B. D.F.	G.L. 8807.6962

BLM Library
Denver Federal Center
Bldg. 50, OC-521
P.O. Box 25047
Denver, CO 80225

TD
195
.E4
E646
1989c
v.2

STRATA DATA INC.

DUAL NORMAL ELECTRIC LOG WITH S.P. AND GAMMA RAY

FILE NO. 5112

COMPANY WOODWARD-CLYDE CONSULTANTS

WELL TW - 15

FIELD TOANA DRAW

COUNTY ELKO STATE NEVADA

LOCATION:

SEC 9 TWP 39N RGE 56E

Other Services: SONIC/CAL. TEMP. LOG

Elevations: KB ___ DF ___ GL ___

Permanent Datum GROUND LEVEL Elev. ___

Log Measured from G.L. 0 Ft. Above Permanent Datum

Drilling Measured from G.L.

Date	08/22/88		
Run No.	ONE		
Depth—Driller	425		
Depth—Logger	414		
Bottom Logged Interval	414		
Top Logged Interval	2		
Casing—Driller	NA @	@	@
Casing—Logger			
Bit Size	10"		
Type Fluid in Hole	FORMATION WATER		
Density and Viscosity			
pH and Fluid Loss		cc	cc
Source of Sample			
Rm @ Meas. Temp.	@ °F	@ °F	@ °F
Rmf @ Meas. Temp.	@ °F	@ °F	@ °F
Rmc @ Meas. Temp.	@ °F	@ °F	@ °F
Source of Rmf and Rmc			
Rm @ BHT	@ °F	@ °F	@ °F
Time Since Circ.			
Max. Rec. Temp. Deg. F.	°F	°F	°F
Equip. No. and Location	102 ELKO		
Recorded By	SPOHR		
Witnessed By	MR. MERBELL		

FOLD HERE

THIS HEADING AND LOG CONFORMS TO API RECOMMENDED STANDARD PRACTICE RP-31

Gamma Ray				Equipment Data				Density			
Run No.	ONE			Run No.							
Tool Model No.	GRS27A20			Tool Model No.							
Serial No.	118			Serial No.							
Diam.	1 3/4			Diam.							
Detect. Model No.	S4			Computer Model No.							
Type	SCINT.			Serial No.							
Length	4"			Source Model No.							
Dist. to Source	NA			Serial No.							
General				Computer Data							
Hoist Truck No.	102										
Auxiliary Equipment											

Logging Data

General				Gamma Ray				Density			
Run No.	Depths From	Depths To	Speed Ft./Min.	T.C. Sec.	Sens. Settings	Zero Div. L or R	API G.R. Units Per Log Div.	T.C. Sec.	Density Scale	Correction Scale	Porosity Scale Data
1	2	414	20	3	235	0					

Remarks: FLUID LEVEL APPROX. 282'. FOAM FROM 282' TO 211'.

Reference Literature:

SPONTANEOUS POTENTIAL Millivolts	DEPTH	RESISTIVITY Ohms m^2/m	

5

GAMMA RAY

RADIATION INTENSITY INCREASES

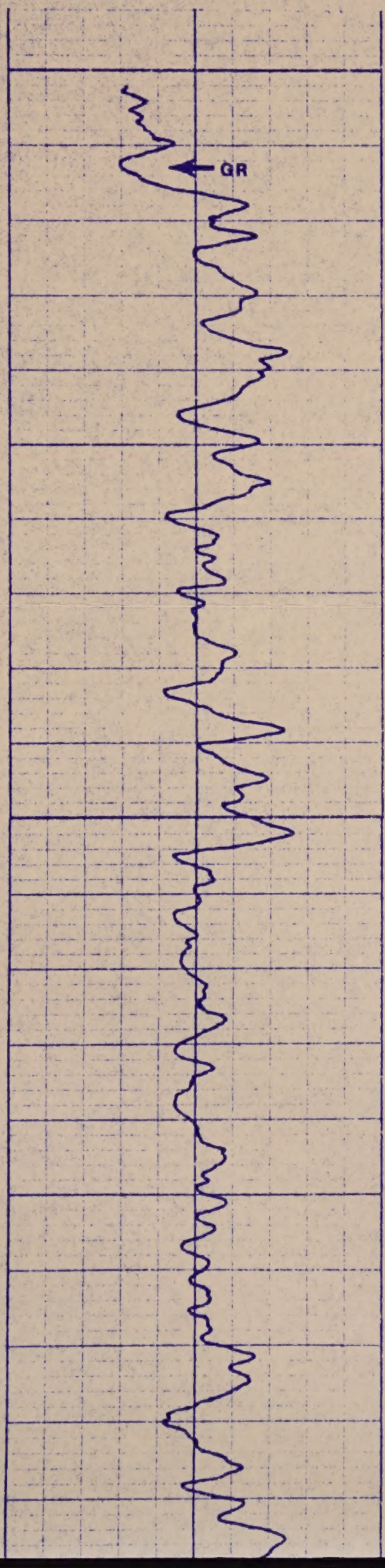
0 API UNITS 120

16" NORMAL

0 50 100

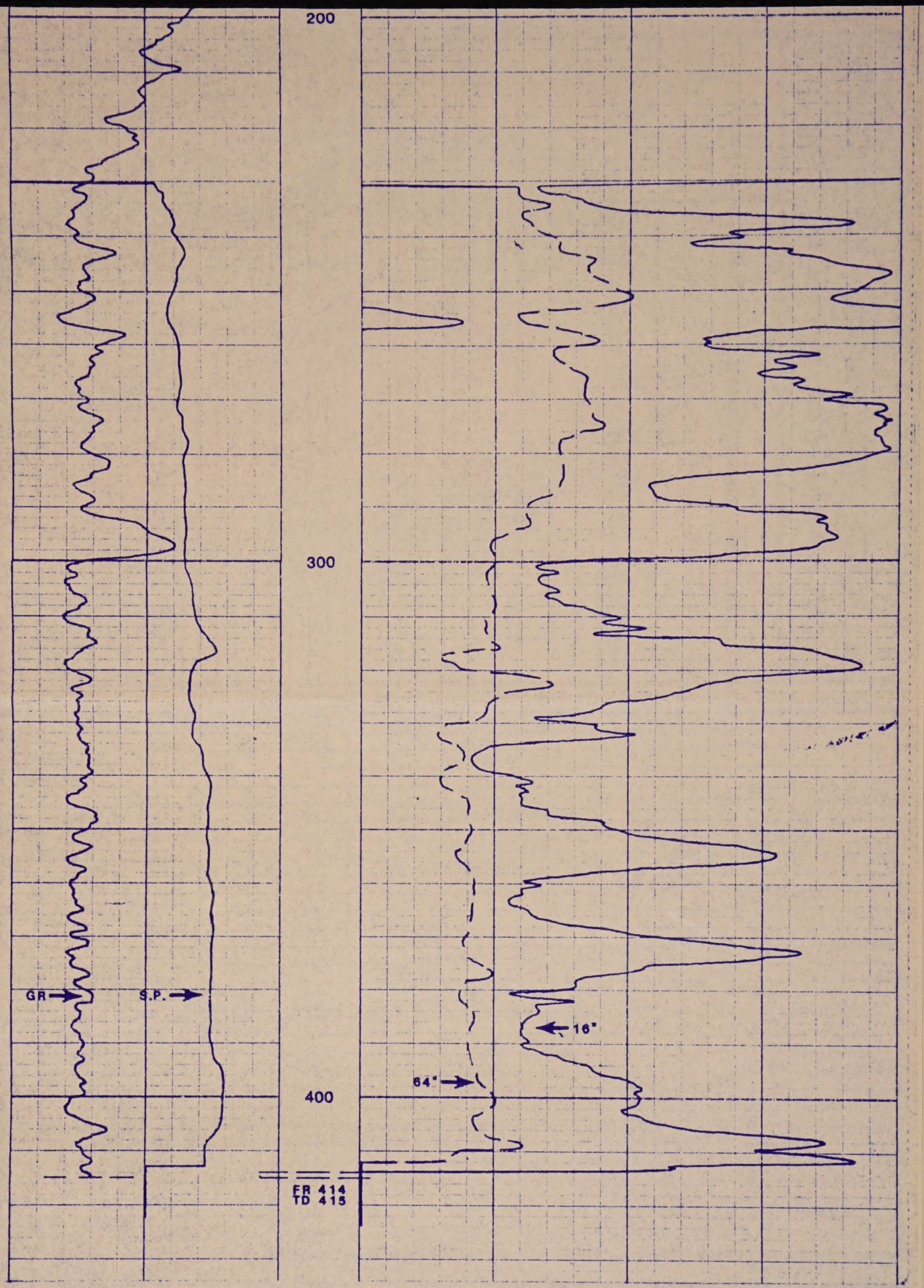
64" NORMAL

0 50 100



0

100



0 API UNITS 120		0 64" NORMAL 50 100	
RADIATION INTENSITY INCREASES GAMMA RAY		0 16" NORMAL 50 100	
− 5 +			
SPONTANEOUS POTENTIAL Millivolts	DEPTH	RESISTIVITY Ohms m^2/m	

Company	WOODWARD–CLYDE CONSULTANTS	Drillers T.D.	425
Well	TW – 15	Log F.R.	414
Field	TOANA DRAW	Log T.D.	415
County	ELKO	Elevations:	
State	NEVADA	K.B. D.F.	G.L.

BLM Library
Denver Federal Center
Bldg. 50, OC-521
P.O. Box 25047
Denver, CO 80225

TD
195
.E4
E646
1989e
v.2

88076962

STRATA DATA INC

SONIC/CALIPER LOG

FILE NO. 5112

COMPANY WOODWARD-CLYDE CONSULTANTS

WELL TW - 15

FIELD TOANA DRAW

COUNTY ELKO STATE NEVADA

LOCATION:

NW 1/4, SW 1/4

SEC 9 TWP 39N RGE 66E

Other Services

DNEL/GR

TEMP. LOG

Permanent Datum GROUND LEVEL Elev.

Log Measured from G.L. 0 Ft. Above Permanent Datum

Drilling Measured from G.L.

Elevations:

KB

DF

GL

Date	08/22/88			
Run No.	ONE			
Depth—Driller	425			
Depth—Logger	415			
Bottom Logged Interval	414 -			
Top Logged Interval	4			
Casing—Driller	NA @	@	@	@
Casing—Logger				
Bit Size	10"			
Type Fluid in Hole	FORMATION WATER			
Density and Viscosity				
pH and Fluid Loss	cc	cc	cc	cc
Source of Sample				
Rm @ Meas. Temp.	@ °F	@ °F	@ °F	@ °F
Rmf @ Meas. Temp.	@ °F	@ °F	@ °F	@ °F
Rmc @ Meas. Temp.	@ °F	@ °F	@ °F	@ °F
Source of Rmf and Rmc				
Rm @ BHT	@ °F	@ °F	@ °F	@ °F
Time Since Circ.				
Max. Rec. Temp. Deg. F.	°F	°F	°F	°F
Equip. No. and Location	102 ELKO			
Recorded By	SPOHR			
Witnessed By	MR. MERRELL			

FOLD HERE

THIS HEADING AND LOG CONFORMS TO API RECOMMENDED STANDARD PRACTICE RP-31

REMARKS FLUID LEVEL APPROX. 282' FOAM FROM 282' TO 211'.

Scale Changes

	Scale Up Hole	Scale Down Hole
Depth		
Type Log		

Equipment Data

	Tool Type	Pad Type	Tool Position	Other
Run No.				

Changes in Mud Type or Additional Samples

Date	Sample No.								
Depth-Driller									
Type Fluid in Hole									
Dens.	Visc.								
pH	Fluid Loss		cc		cc				
Source of Sample									
Rm @ Meas. Temp.		@ °F		@ °F		@ °F		@ °F	
Rmf @ Meas. Temp.		@ °F		@ °F		@ °F		@ °F	
Rmc @ Meas. Temp.		@ °F		@ °F		@ °F		@ °F	
Source Rmf	Rmc								
Rm @ BHT		@ °F		@ °F		@ °F		@ °F	
Rmf @ BHT		@ °F		@ °F		@ °F		@ °F	
Rmc @ BHT		@ °F		@ °F		@ °F		@ °F	

SONIC

CALIPER

DEPTH

HOLE SIZE - INCHES

6 — 16

MICROSECONDS

50 — 250

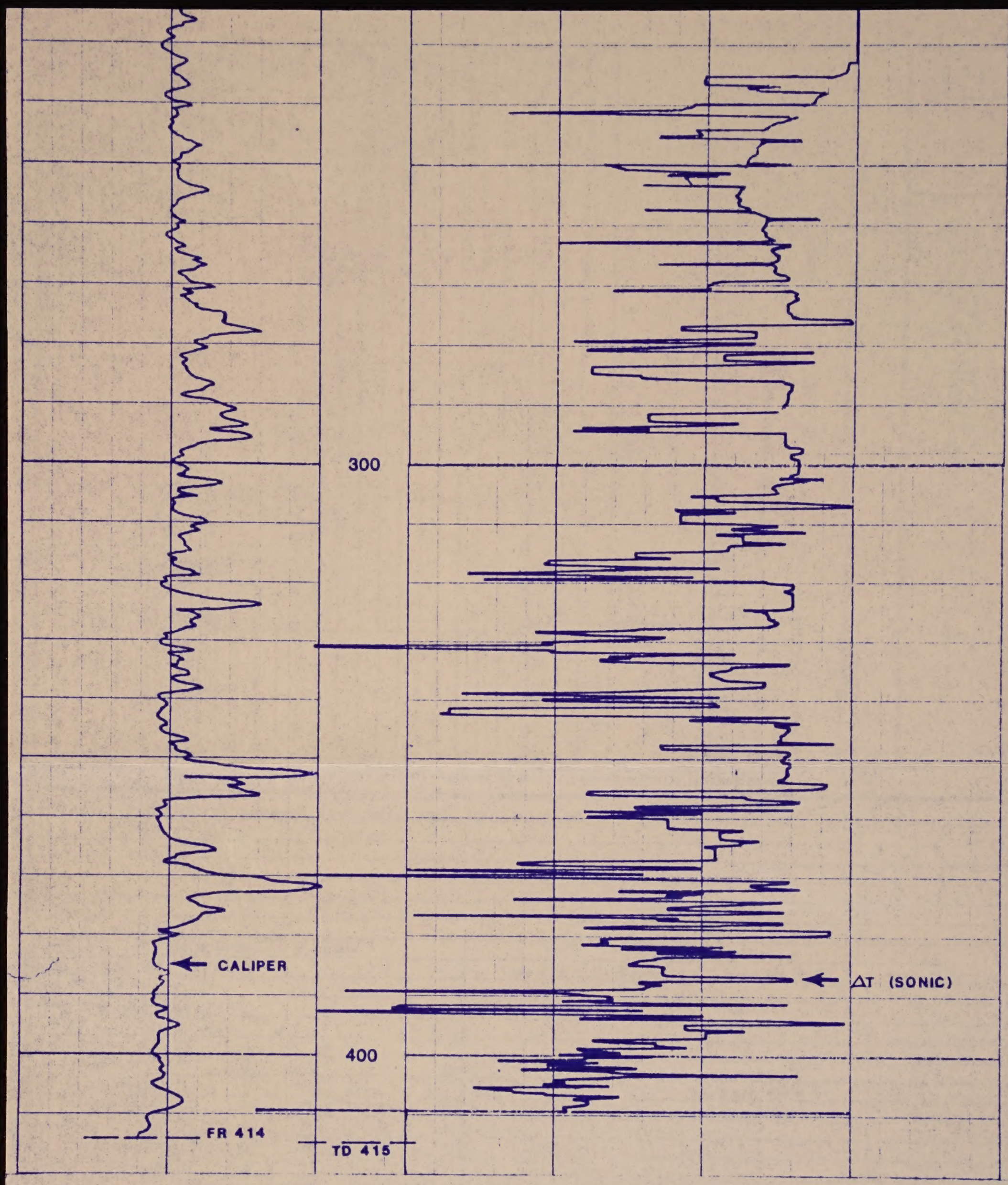
5" = 100'

0

CALIPER

100

200



6	16	50	250
HOLE SIZE - INCHES		MICROSECONDS	
CALIPER	DEPTH	**SONIC**	

Company	WOODWARD–CLYDE CONSULTANTS	Drillers T.D.	425	
Well	TW – 15	Log F.R.	414	
Field	TOANA DRAW	Log T.D.	415	
County	ELKO	Elevations:		
State	NEVADA	K.B.	D.F.	G.L.

BLM Library
Denver Federal Center
Bldg. 50, OC-521
P.O. Box 25047
Denver, CO 80225

TD
195
.E4
E646
1989e
v.2

88076962

TEMPERATURE LOG

STRATA DATA INC

FILE NO 5112

COMPANY	WOODWARD-CLYDE CONSULTANTS
WELL	TW - 15
FIELD	TOANA DRAW
COUNTY	ELKO
STATE	NEVADA
LOCATION:	NW 1/4, SW 1/4
SEC	9
TWP	39N
RGE	66E
Other Services	DNEL/GR SONIC/CAL.

Permanent Datum GROUND LEVEL Elev. ______
Log Measured from G.L. 0 Ft. Above Permanent Datum
Drilling Measured from G.L.

Elevations: KB ____ DF ____ GL ____

Date	08/22/88			
Run No	ONE			
Depth—Driller	425			
Depth—Logger	415			
Bottom Logged Interval	415			
Top Logged Interval	200			
Casing—Driller	NA @	@	@	@
Casing—Logger				
Bit Size	10"			
Type Fluid in Hole	FORMATION WATER			
Density and Viscosity				
pH and Fluid Loss	cc	cc	cc	cc
Source of Sample				
Rm @ Meas. Temp	@ F	@ F	@ F	@ F
Rmf @ Meas. Temp	@ F	@ F	@ F	@ F
Rmc @ Meas. Temp	@ F	@ F	@ F	@ F
Source of Rmf and Rmc				
Rm @ BHT	@ F	@ F	@ F	@ F
Time Since Circ				
Max. Rec. Temp Deg. F	84 F	F	F	F
Equip. No and Location	102 ELKO			
Recorded By	SPOHR			
Witnessed By	MR. MERRELL			

FOLD HERE ↓

THIS HEADING AND LOG CONFORMS TO API RECOMMENDED STANDARD PRACTICE RP 11

REMARKS FLUID LEVEL APPROX. 282'. FOAM FROM 282' TO 211'.

Changes in Mud Type or Additional Samples		
Date / Sample No.		
Depth-Driller		
Type Fluid in Hole		
Dens / Visc.		
pH / Fluid Loss	cc	cc
Source of Sample		
Rm @ Meas. Temp	@ F	@ F
Rmf @ Meas. Temp	@ F	@ F
Rmc @ Meas. Temp	@ F	@ F
Source Rmf / Rmc		
Rm @ BHT	@ F	@ F
Rmf @ BHT	@ F	@ F
Rmc @ BHT	@ F	@ F

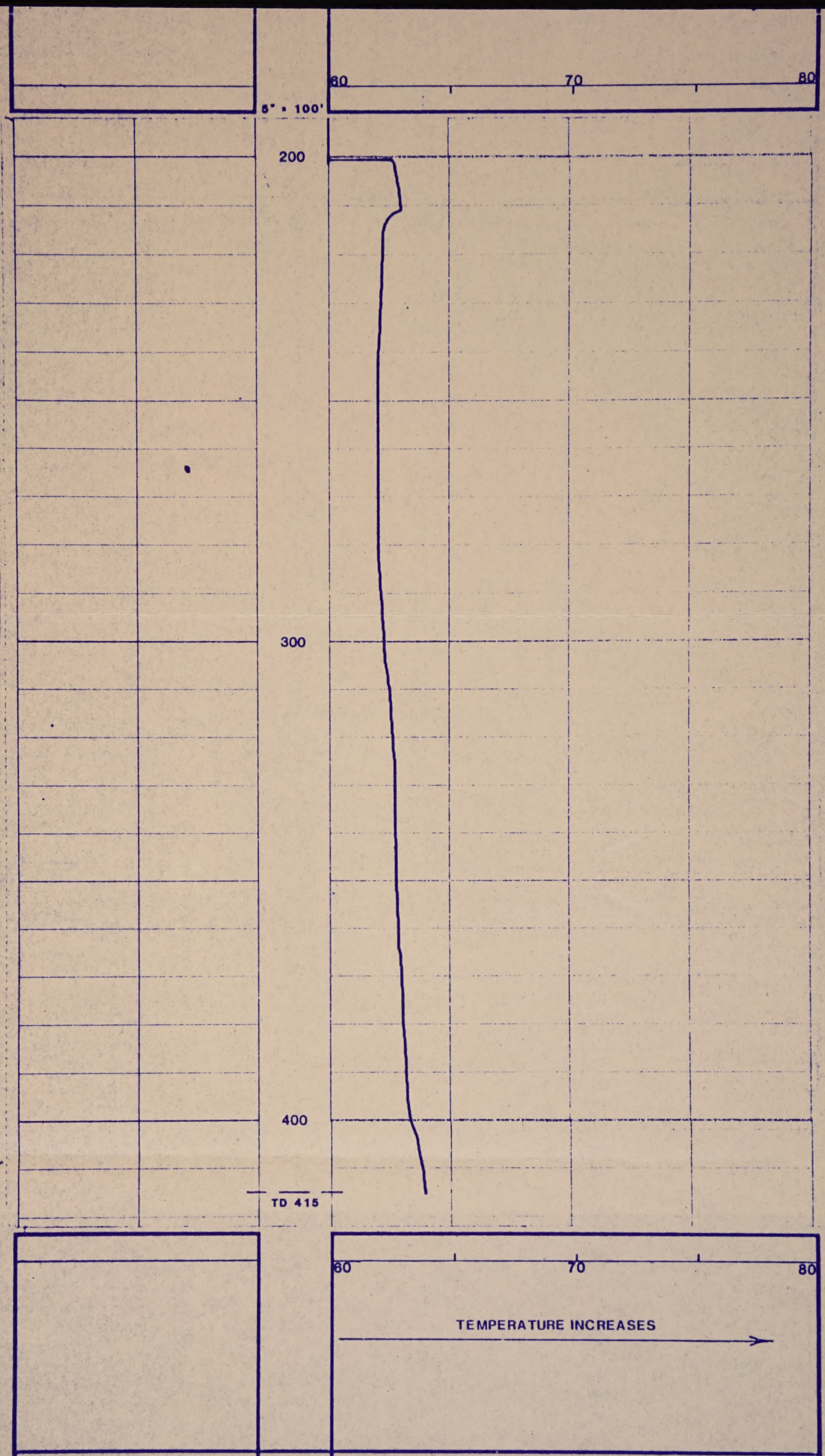
Scale Changes

Type Log	Depth	Scale Up Hole	Scale Down Hole

Equipment Data

Run No.	Tool Type	Pad Type	Tool Position	Other
ONE	TEMP.		FREE	COMPROBE

	DEPTH	TEMPERATURE DEGREES F
		TEMPERATURE INCREASES →



	DEPTH	TEMPERATURE DEGREES F

Company	WOODWARD-CLYDE CONSULTANTS	Drillers T.D.	425	
Well	TW - 15	Log F.R.	415	
Field	TOANA DRAW	Log T.D.	415	
County	ELKO	Elevations:		
State	NEVADA	K.B.	D.F.	G.L.

BLM Library
Denver Federal Center
Bldg. 50, OC-521
P.O. Box 25047
Denver, CO 80225

TD
195
.E4
E646
1989e
v.2

88076962

GAMMA RAY LOG

STRATA DATA INC.

FILE NO. 5130

COMPANY WOODWARD–CLYDE CONSULTANTS
WELL TW - 16
FIELD TOANA DRAW
COUNTY ELKO STATE NEVADA
LOCATION:

SEC ____ TWP ____ RGE ____

Other Services: NONE

Permanent Datum GROUND LEVEL Elev. ____
Log Measured from G.L. 0 Ft. Above Permanent Datum
Drilling Measured from G.L.

Elevations: KB ____ DF ____ GL ____

Date	11/30/88			
Run No.	ONE			
Depth—Driller	600			
Depth—Logger	279			
Bottom Logged Interval	279			
Top Logged Interval	0			
Casing—Driller	N/A @	@	@	@
Casing—Logger	N/A			
Bit Size	10"			
Type Fluid in Hole	DRY (AIR DRILLED)			
Density and Viscosity				
pH and Fluid Loss	cc	cc	cc	cc
Source of Sample				
Rm @ Meas. Temp.	@ °F	@ °F	@ °F	@ °F
Rmf @ Meas. Temp.	@ °F	@ °F	@ °F	@ °F
Rmc @ Meas. Temp.	@ °F	@ °F	@ °F	@ °F
Source of Rmf and Rmc				
Rm @ BHT	@ °F	@ °F	@ °F	@ °F
Time Since Circ.				
Max. Rec. Temp. Deg. F.	°F	°F	°F	°F
Equip. No. and Location	102 ELKO			
Recorded By	MC DONALD			
Witnessed By	MR. REYNOLDS			

FOLD HERE

THIS HEADING AND LOG CONFORMS TO API RECOMMENDED STANDARD PRACTICE RP 31

Gamma Ray — Equipment Data — Density

Gamma Ray				Density			
Run No.	ONE			Run No.			
Tool Model No.	GRS27A20			Tool Model No.			
Serial No.				Serial No.			
Diam.	1 3/4"			Diam.			
Detect. Model No.	84			Computer Model No.			
Type	SCINT.			Serial No.			
Length	4"			Source Model No.			
Dist. to Source	N/A			Serial No.			

General				Computer Data			
Hoist Truck No.							
Auxiliary Equipment							

Logging Data

Run No.	Depths From	Depths To	Speed Ft./Min.	T.C. Sec.	Sens. Settings	Zero Div. L or R	API G.R. Units Per Log Div.	T.C. Sec.	Density Scale	Correction Scale	Porosity Scale Data
1	0	279	25	3	174	5L	12				

Remarks:
LOGGING TOOL WOULD NOT GO BELOW 279' DUE TO SWELLING CLAYS.
LACK OF WATER OR MUD IN HOLE PREVENTED RUNNING OTHER LOGS.

Reference Literature:

GAMMA RAY	DEPTH	

5" = 100'

0

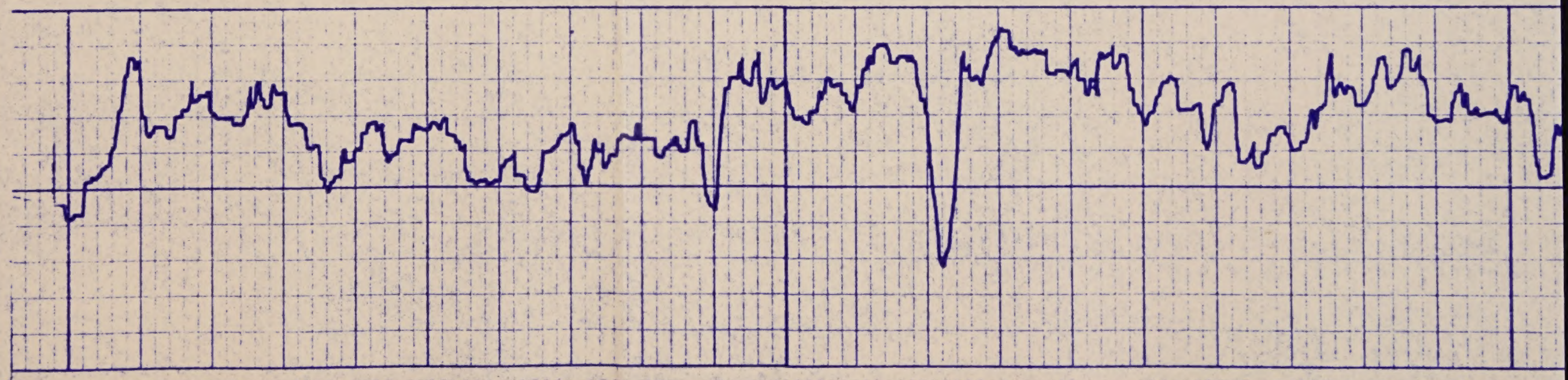
100

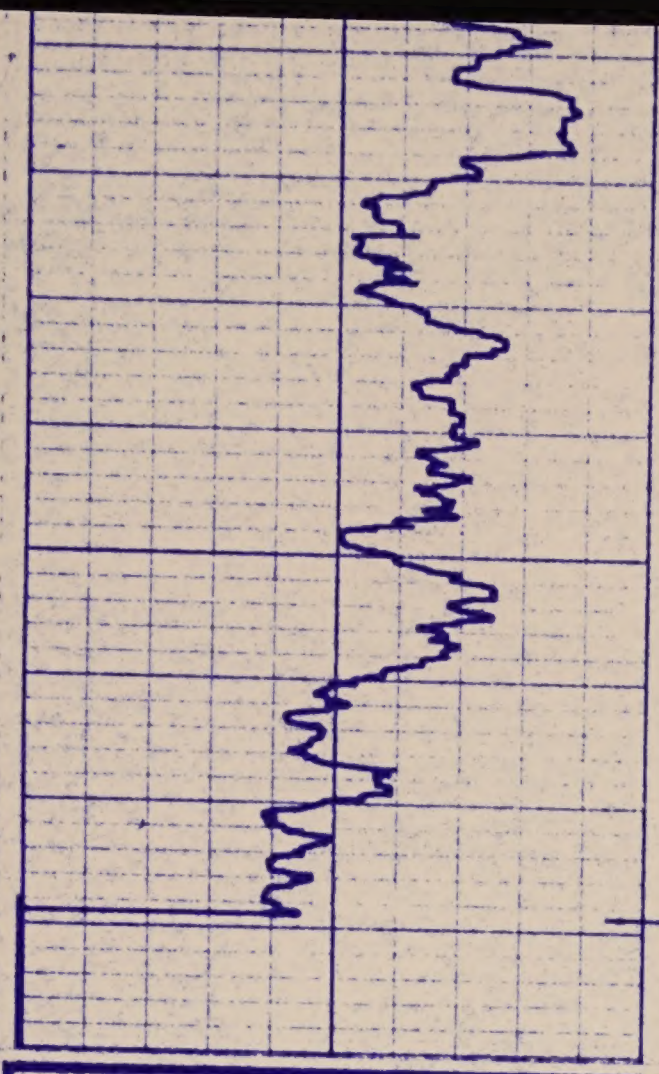
200

API UNITS

180

60





60 API UNITS 180

GAMMA RAY

DEPTH

Company	WOODWARD-CLYDE CONSULTANTS	Drillers T.D.	600
Well	TW - 16	Log F.R.	279
Field	TOANA DRAW	Log T.D.	279
County	ELKO	Elevations:	
State	NEVADA	K.B.	D.F. G.L.

BLM Library
Denver Federal Center
Bldg. 50, OC-521
P.O. Box 25047
Denver, CO 80225

TD
195
.E4
E646
1989e
v.2
88076962

STRATA DATA INC.

DUAL NORMAL ELECTRIC LOG WITH S.P. AND GAMMA RAY

FILE NO. 5135

COMPANY WOODWARD-CLYDE CONSULTANTS

WELL MW - 17

FIELD TOANA DRAW

COUNTY ELKO STATE NEVADA

LOCATION: SEC 35 TWP 41N RGE 65W

NW, NE

Other Services: NONE

Permanent Datum GROUND LEVEL Elev.

Log Measured from G.L. 0 Ft. Above Permanent Datum

Drilling Measured from G.L.

Elevations: KB DF GL

Date	02/14/89			
Run No.	ONE			
Depth—Driller	650			
Depth—Logger	636			
Bottom Logged Interval	635			
Top Logged Interval	0			
Casing—Driller	NA @	@	@	@
Casing—Logger	NA			
Bit Size	FORMATION			
Type Fluid in Hole	WATER			
Density and Viscosity				
pH and Fluid Loss				
Source of Sample				
Rm @ Meas. Temp.	@ °F	@ °F	@ °F	@ °F
Rmf @ Meas. Temp.	@ °F	@ °F	@ °F	@ °F
Rmc @ Meas. Temp.	@ °F	@ °F	@ °F	@ °F
Source of Rmf and Rmc				
Rm @ BHT	@ °F	@ °F	@ °F	@ °F
Time Since Circ.				
Max. Rec. Temp. Deg. F.				
Equip. No. and Location	102 ELKO			
Recorded By	SPOHR			
Witnessed By	MR. TEAGUE			

FOLD HERE

THIS HEADING AND LOG CONFORMS TO API RECOMMENDED STANDARD PRACTICE RP-31

Gamma Ray — Equipment Data

Run No.	ONE		
Tool Model No.			
Serial No.	GRS27A20		
Diam.	1 3/4"		
Detect. Model No.	S-4		
Type	SCINT.		
Length	4"		
Dist. to Source	NA		

Density

Run No.			
Tool Model No.			
Serial No.			
Diam.			
Computer Model No.			
Serial No.			
Source Model No.			
Serial No.			

General

Hoist Truck No.	102		
Auxiliary Equipment			

Computer Data

Logging Data

General				Gamma Ray				Density			
Run No.	Depths From	Depths To	Speed Ft./Min.	T.C. Sec.	Sens. Settings	Zero Div. L or R	API G.R. Units Per Log Div.	T.C. Sec.	Density Scale	Correction Scale	Porosity Scale Data
1	0	635	20	3	140	3L	15				

Remarks:

GAMMA RAY LOG NOT RECORDED FROM BOTTOM DUE TO BAD HOLE CONDITIONS.

Reference Literature:

SPONTANEOUS POTENTIAL Millivolts	DEPTH	RESISTIVITY Ohms m^2/m	

10

\- +

GAMMA RAY

RADIATION INTENSITY INCREASES

45 API UNITS 195

5" = 100'

16" NORMAL

0 50 100

64" NORMAL

0 50 100

0

GR

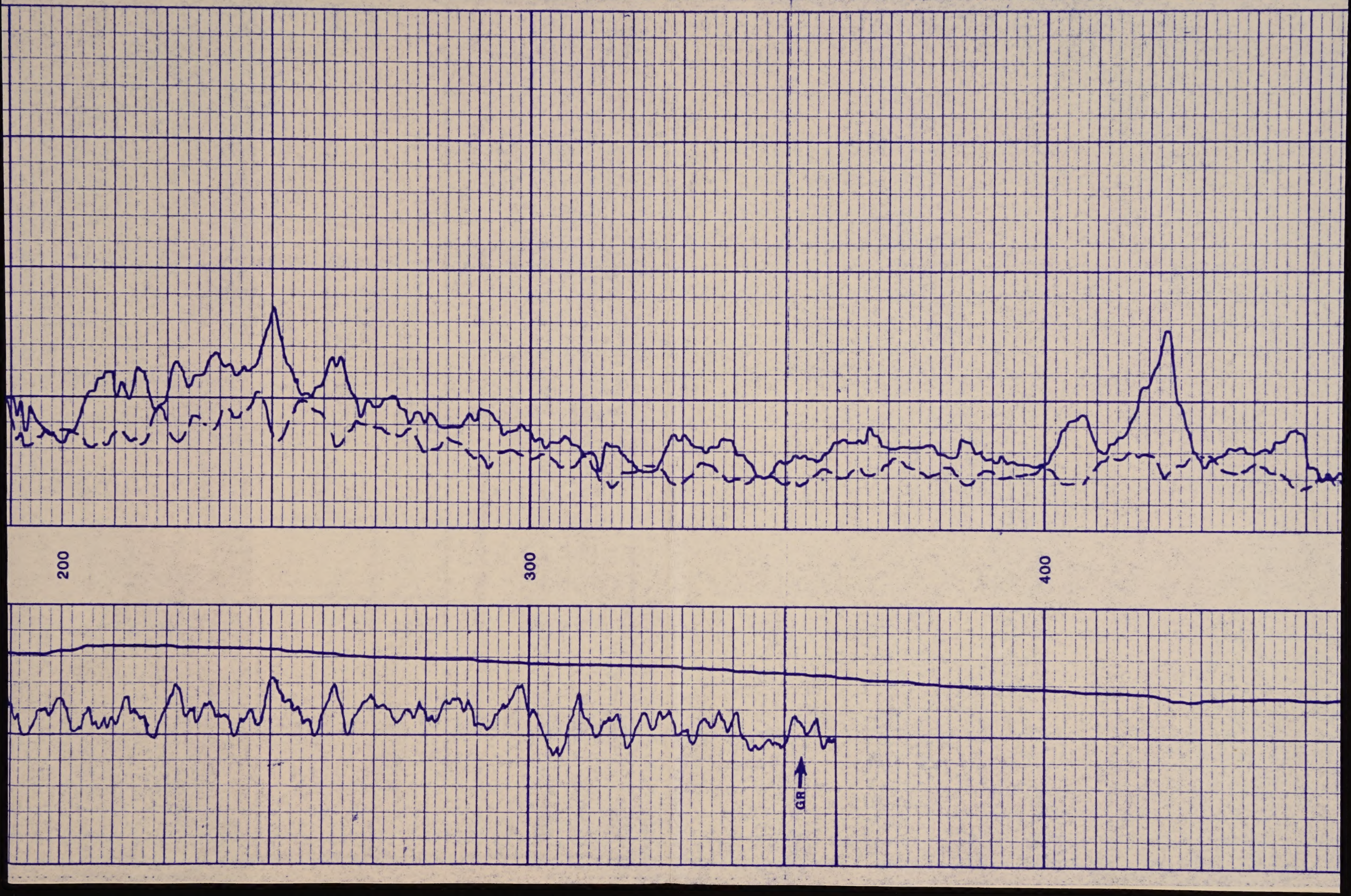
SP

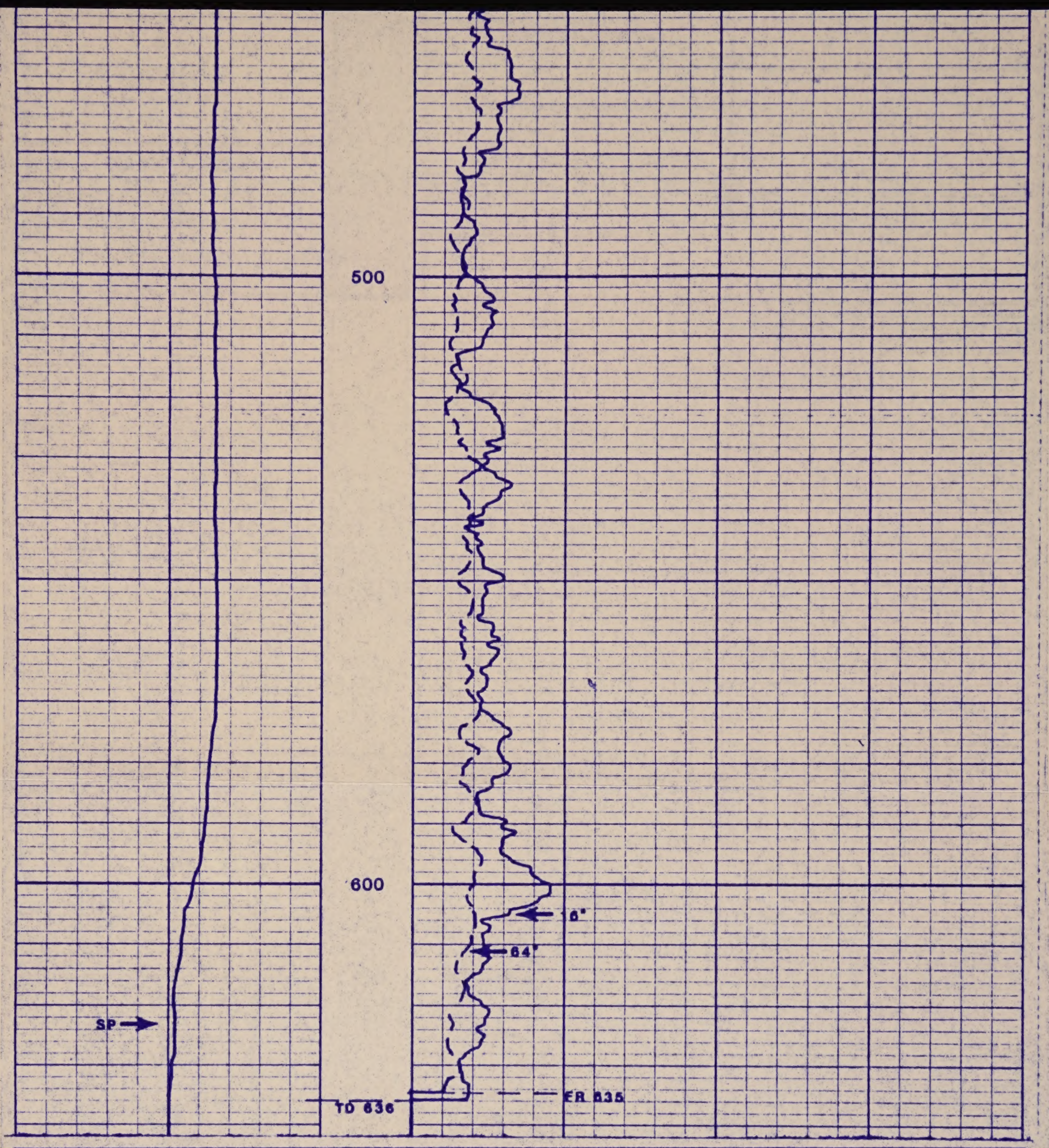
100

FLUID LEVEL

64"

16"


200
300
400
GR

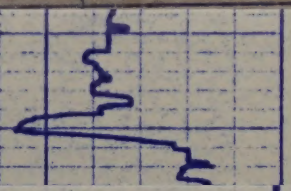


45 API UNITS 195		0 64" NORMAL 50 100	
RADIATION INTENSITY INCREASES GAMMA RAY			
− + 10		0 16" NORMAL 50 100	
SPONTANEOUS POTENTIAL Millivolts	**DEPTH**	**RESISTIVITY** Ohms m^2/m	

Company	WOODWARD–CLYDE CONSULTANTS		Drillers T.D.	650	
Well	MW – 17		Log F.R.	635	
Field	TOANA DRAW		Log T.D.	636	
County	ELKO		Elevations:		
State	NEVADA		K.B.	D.F.	G.L.

BLM Library
Denver Federal Center
Bldg. 50, OC-521
P.O. Box 25047
Denver, CO 80225

TD
195
.E4
E646
1989e
v.2
88076962



GAMMA RAY	DEPTH	

Company	WOODWARD–CLYDE CONSULTANTS		Drillers T.D.	600	
Well	TW – 16		Log F.R.	279	
Field	TOANA DRAW		Log T.D.	279	
County	ELKO		Elevations:		
State	NEVADA		K.B.	D.F.	G.L.

BLM Library
Denver Federal Center
Bldg. 50, OC-521
P.O. Box 25047
Denver, CO 80225

TD
195
.E4
E646
1989e
v.2

88076962

APPENDIX E
LITHOLOGIC AND WELL CONSTRUCTION LOGS

Woodward-Clyde Consultants

PROJECT NAME Thousand Springs Energy Project NO. 90270B

BORING LOCATION MW -1 SE1/4, SE1/4, Section 35, T42N, R65E		ELEVATION AND DATUM 5385 ft. MSL (ground surface)	
DRILLING AGENCY R.D. Reynolds Drilling	DRILLER R. Reynolds	DATE STARTED 8/9/88 DATE FINISHED 8/16/88	
DRILLING EQUIPMENT Schram Rota Drill		COMPLETION DEPTH 200 ft.	SAMPLER drill cuttings
DRILLING METHOD Air Rotary w/ foam	DRILL BIT 6" drag bit	NO. OF SAMPLES / DIST.	UNDIST.
SIZE AND TYPE OF CASING 2" Schedule 80 PVC		WATER LEVEL / FIRST	COMPL. --- / 24 HRS. ---
TYPE OF PERFORATION 2" Schedule 80 Slotted (0.020") PVC	FROM 180 TO 200	LOGGED BY: H. Merrell	CHECKED BY: J. Strandberg
SIZE AND TYPE OF PACK Wadsworth Gravel	FROM 160 TO 220 50 TO 150		
TYPE OF SEAL NO. 1 Bentonite Bentonite & gravel	FROM 150 TO 160 FROM 220 TO 270		
NO. 2 Cement - Grout	FROM 0 TO 50 FROM 270 TO 540		

DEPTH (feet)	LITHOLOGIC DESCRIPTION	Well Completion Diagram	DEPTH (feet)	SAMPLES	REMARKS (Drill Rate, Fluid Loss, Odor, etc.)
0	Clay: lt. tan, soft		0		
10	Gravel: coarse-grained, abundant black fragments		10		
20	Clay & gravel		20		
30	Sand: lt. green-gray, coarse to medium-grained, unconsolidated, sub-angular		30		
40	Clay: lt. tan, soft		40		
50			50		
60			60		
70	Sand: tan, fine to coarse-grained, sub-angular to sub-rounded, poorly sorted; minor white clay; minor lt. purple quartz		70		
80			80		
90			90		
100			100		
110			110		
120			120		
130			130		
140			140		

FIELD LOG OF BORING NO. MW-1 SHEET 1 OF 4

LITHOLOGIC DESCRIPTION	Well Completion Diagram	DEPTH (feet)	SAMPLES	REMARKS (Drill Rate, Fluid Loss, Odor, etc.)
Sand: tan, fine to coarse-grained, sub-angular to sub-rounded, poorly sorted, unconsolidated; minor white clay; minor lt. purple quartz		150		
		160		
		170		
		180		
		190		
		200		
Sand: as above; minor purple chert		210		
		220		
As above; abundant white tuff				
Sand: as above		230		
		240		
		250		
		260		
Volcanic tuff: lt. green; minor sand: lt. green, fine-grained; clay: lt. gray-white		270		
		280		
		290		
		300		
		310		
		320		

FIELD LOG OF BORING NO. MW-1 SHEET 2 OF 4

LITHOLOGIC DESCRIPTION	Well Completion Diagram	DEPTH (feet)	SAMPLES	REMARKS (Drill Rate, Fluid Loss, Odor, etc.)
Volcanic tuff: lt. green, hard; minor sand: lt. green, fine-grained		330		
		340		
Sand: lt. green, fine-grained, unconsolidated; minor chert: lt. brown; minor tuff: lt. gray		350		
		360		
		370		
Clay: lt. green; minor sand: lt. gray, fine-grained		380		
		390		
Sand: lt. gray, fine-grained,sub-angular to sub-rounded, unconsolidated; minor clay: lt. green, semi-consolidated		400		
As above; minor chert: lt. brown		410		
		420		
		430		
Sand		440		
		450		
Clay & sand: lt. green; minor chert: lt. brown		460		
		470		
		480		
As above; trace pyrite crystals; minor sand: lt. gray-green		490		
		500		At 500 ft. water produced has sulfurous smell

FIELD LOG OF BORING NO. MW-1 SHEET 3 OF 4

PROJECT NAME Thousand Springs Energy Project NO. 90270B

LITHOLOGIC DESCRIPTION	Well Completion Diagram	DEPTH (feet)	SAMPLES	REMARKS (Drill Rate, Fluid Loss, Odor, etc.)
Sandy clay: lt. green-gray; minor sand, lt. green, fine-grained; trace of chert		510		Well continues to produce sulfurous water. Water is not salty to taste.
Clay: dark olive green, semi-consolidtaed		520		
Clayey sand: lt. green; volcanic tuff: dark gray; trace of pyrite		530		
Total Depth 540 ft.		540		
		550		
		560		
		570		
		580		
		590		
		600		
		610		
		620		
		630		
		640		
		650		
		660		
		670		
		680		

FIELD LOG OF BORING NO. MW-1 SHEET 4 OF 4

Woodward-Clyde Consultants

PROJECT NAME Thousand Springs Energy Project NO. 90270B

BORING LOCATION MW -2 SW1/4, SW1/4, Section 23, T40N, R65E		ELEVATION AND DATUM 5385 ft. MSL (ground surface)	
DRILLING AGENCY R.D. Reynolds Drilling	DRILLER K. Stubbs	DATE STARTED 7/20/88 DATE FINISHED 8/19/88	
DRILLING EQUIPMENT Schram Rota Drill		COMPLETION DEPTH 290 ft.	SAMPLER drill cuttings
DRILLING METHOD Air and Mud Rotary	DRILL BIT 5-3/4" tri-cone roller bit	NO. OF SAMPLES / DIST.	UNDIST.
SIZE AND TYPE OF CASING 2" Schedule 80 PVC		WATER LEVEL / FIRST	COMPL. --- / 24 HRS. ---
TYPE OF PERFORATION 2" Schedule 80 Slotted (0.020") PVC	FROM 270 TO 290	LOGGED BY: H. Merrell	CHECKED BY: K. Teague
SIZE AND TYPE OF PACK Wadsworth Gravel	FROM 62 TO 181 FROM 235 TO 310		
TYPE OF SEAL NO. 1 Bentonite	FROM 181 TO 235 FROM 310 TO 446		
TYPE OF SEAL NO. 2 Cement - Grout Drilling Mud	FROM 0 TO 62 FROM 446 TO 607		

DEPTH (feet)	LITHOLOGIC DESCRIPTION	Well Completion Diagram	DEPTH (feet)	SAMPLES	REMARKS (Drill Rate, Fluid Loss, Odor, etc.)
10	Clay: lt. tan, some fragments of dark gray minerals		10		Drilling w/ air Water injected
20			20		
30	Gravel: gray to black, angular fragments 1/4" to 1/2"		30		Convert to mud rotary
40	Clay: lt. tan, soft, gummy		40		
50			50		
60			60		
70	Gravel: dark gray to black, fine, angular		70		
80	Clay: lt. tan, soft, gummy		80		
90			90		
100			100		
110	Gravel: black to dark tan; sand: lt. brown to black, very coarse; minor chert & quartz		110		Water encountered 112 ft. to 118 ft.
120			120		
130	Clay: lt. tan, soft, gummy		130		
140			140		

FIELD LOG OF BORING NO. MW-2 SHEET 1 OF 4

Woodward-Clyde Consultants

PROJECT NAME Thousand Springs Energy Project NO. 90270B

LITHOLOGIC DESCRIPTION	Well Completion Diagram	DEPTH (feet)	SAMPLES	REMARKS (Drill Rate, Fluid Loss, Odor, etc.)
Sand: black to dark tan, very coarse-grained, angular to sub-angular, unconsolidated; minor white limestone fragments		150		
As above; minor carbonate cement				Water encountered 157 ft. to 170 ft.
		160		
As above; sand: dark gray, very coarse-grained, composed of chert & feldspar; minor green calcareous shale clasts				
		170		
Clay, lt. tan, soft, gummy				
		180		
		190		
		200		
		210		
As above; minor sand: dark gray, fine to coarse-grained, unconsolidated		220		
		230		
		240		
Sand: dark gray to tan, coarse-grained, poorly consolidated; clay: lt. gray		250		
		260		
		270		
Sand: dark gray, very coarse-grained, poorly consolidated		280		Water encountered 278 ft. to 290 ft.
		290		
Clay, lt. tan, soft		300		
		310		
		320		

FIELD LOG OF BORING NO. MW-2 SHEET 2 OF 4

Woodward-Clyde Consultants

PROJECT NAME Thousand Springs Energy Project NO. 90270B

LITHOLOGIC DESCRIPTION	Well Completion Diagram	DEPTH (feet)	SAMPLES	REMARKS (Drill Rate, Fluid Loss, Odor, etc.)
Clay: lt. tan, soft, gummy		330		
		340		
		350		
As above; minor varicolored sandstone & shale clasts		360		
		370		
		380		
		390		
		400		
		410		
As above, varicolored clasts increase to 20 %		420		
		430		
As above, varicolored clasts decrease to trace		440		Water encountered 440 ft. to 455 ft.
Sand: dark gray to varicolored, very coarse-grained, sub-angular; minor clay: lt. gray, gummy		450		
Clay: lt. gray, soft, gummy		460		
		470		
		480		
		490		Water encountered 495 ft. to 507 ft.
Sand: dark gray to varicolored, very coarse grained, sub-angular; minor clay: lt. gray, gummy		500		

FIELD LOG OF BORING NO. MW-2 SHEET 3 OF 4

PROJECT NAME Thousand Springs Energy Project NO. 90270B

LITHOLOGIC DESCRIPTION	Well Completion Diagram	DEPTH (feet)	SAMPLES	REMARKS (Drill Rate, Fluid Loss, Odor, etc.)
Clay: lt. tan, soft, gummy		510		
		520		
		530		
		540		
		550		
		560		
		570		
		580		
		590		
		600		
Total depth 607 ft.		610		
		620		
		630		
		640		
		650		
		660		
		670		
		680		

FIELD LOG OF BORING NO. MW-2 SHEET 4 OF 4

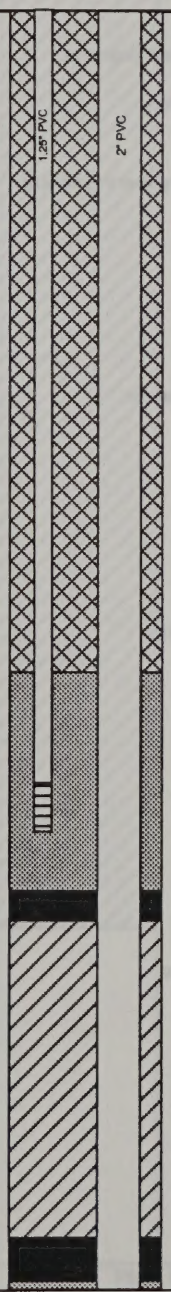
Woodward-Clyde Consultants

PROJECT NAME Thousand Springs Energy Project NO. 90270B

BORING LOCATION MW-3 SW 1/4, NW1/4, Section 5, T39N, R66E		ELEVATION AND DATUM 5710 ft. MSL (ground surface)	
DRILLING AGENCY R. D. Reynolds Drilling	DRILLER R. Reynolds	DATE STARTED 6/21/88 DATE FINISHED 7/25/88	
DRILLING EQUIPMENT Schram Rota Drill		COMPLETION DEPTH 180 ft. (1.25") 320 ft. (2.00")	SAMPLER cuttings
DRILLING METHOD Air and Mud Rotary	DRILL BIT 6" drag bit	NO. OF SAMPLES DIST. 19	UNDIST. 0
SIZE AND TYPE OF CASING 2" Schedule 80 PVC 1-1/4" Schedule 40 PVC		WATER LEVEL FIRST	COMPL. --- 24 HRS. ---
TYPE OF PERFORATION 2" Schedule 80 Slotted (0.020") PVC 1-1/4" Saw Cut PVC	FROM 160 TO 180 FROM 300 TO 320	LOGGED BY: M. Popoff R. Siegel	CHECKED BY: J. Strandberg
SIZE AND TYPE OF PACK Fine Sand Wadsworth Gravel	FROM 145 TO 195 FROM 277 TO 288 FROM 288 TO 330		
TYPE OF SEAL NO. 1 Bentonite Bentonite and Gravel	FROM 195 TO 200 FROM 340 TO 350 FROM 257 TO 277 FROM 200 TO 270		
NO. 2 Cement - Grout	FROM 0 TO 145		

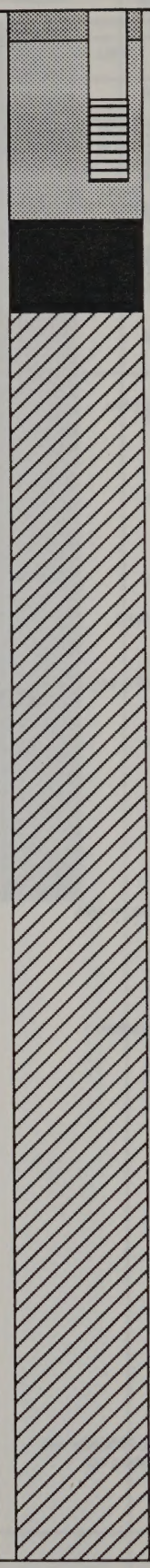
DEPTH (feet)	LITHOLOGIC DESCRIPTION
0	Desert Top Soil Gravelly clay: angular fragments of gravel, brown to dark tan, dry
20	
40	Increase in coarse gravel content.
60	Sandy to gravelly clay-clayey gravel: 30% very coarse sand, > 40% clay, 30% coarse gravels..
80	Clayey sandy gravel: 65% medium to coarse gravels, 25% very coarse sand, and 10% clay
100	
120	Sandy gravel: same as above- 55% fine- medium gravels, ~ 45% very coarse sand.
140	
160	Gravelly sand and clay to clayey sand: with 10 - 15% medium gravels. Note: clay-rich material may be volcanic ash.
180	
200	
220	
240	
260	Clayey gravelly sand: 65% medium to very coarse sand, 20% clay -silt, 15% coarse gravels, lt brown color. Fines might be washing out.
280	

Well Completion Diagram



DEPTH (feet)	SAMPLES	REMARKS (Drill Rate, Fluid Loss, Odor, etc.)
0		Drilling with water and quick foam.
20		Easy drilling
40		@48' drill pipe rattling, coarser gravel
60		
80		
100	3-1	SAMPLED @ 92'
120	3-2	SAMPLED @ 130'
140		
160		First Water encountered between 159 to 160 feet.
180	3-3	SAMPLED @ 171'
200	3-4	SAMPLED AT 213'
220		Poor water production @221'
240	3-5	SAMPLED AT 238'
260	3-6	SAMPLED AT 268'
280		

FIELD LOG OF BORING NO. MW-3 SHEET 1 OF 3

LITHOLOGIC DESCRIPTION	Well Completion Diagram	DEPTH (feet)	SAMPLES	REMARKS (Drill Rate, Fluid Loss, Odor, etc.)
Gravel to sandy gravel: angular, black, minor sand and clay.		300	3-7	SAMPLED AT 295'
Gravel : 90% pebbles, 10% granules; tuff: white; metamorphic ? clasts: lime to olive-green (limestone, black basalt or diabase?)		320	3-8	SAMPLED AT 315' Increase in water production @ 320'
		340	3-9	SAMPLED AT 334'
		360	3-10	SAMPLED AT 354' Hard drilling at 363'.
Same as above, but increase in clay-sized particles, less fragments.		380	3-11 3-12	SAMPLED AT 374' SAMPLED AT 386'
Increase in coarse material at 385'; very coarse gravels.				Discharge tube clogging.
Increase in sand to 5 -10 percent, sediment becoming finer in grain size.		400		Convert to mud rotary
		420		
		440		High water production
Sandy gravel to gravelly sand: decrease in coarser fraction.		460	3-13	SAMPLED AT 457'
Clay lense from 470 to 474'.				Slow drilling at 475'
Clay lense from 478 to 480'.		480		Rods chattering at 480'
		500	3-14	SAMPLED AT 500'
Mostly coarse sand; increase in gravel content at 512'.				Sample might be sloughed material from above. Insufficient cuttings being returned to sample. Adding detergent foam at 535'.
		520		
		540		Loosing mud to the formation.
		560		Constant mud loss to the formation.
Sandy gravel to gravelly sand		580		
Gravelly material washing out from above; increase in coarse sand.		600	3-15	SAMPLED AT 600'
		620	3-16	SAMPLED AT 625'
		640		Fast drilling rate, rods are rattling, good returns.
Sand medium to coarse grained.			3-17	SAMPLED AT 650'

FIELD LOG OF BORING NO. MW-3 SHEET 2 OF 3

Woodward-Clyde Consultants

PROJECT NAME Thousand Springs Energy Project NO. 90270B

DEPTH (feet)	LITHOLOGIC DESCRIPTION	Well Completion Diagram	DEPTH (feet)	SAMPLES	REMARKS (Drill Rate, Fluid Loss, Odor, etc.)
	Sand: medium to coarse-grained, same as above.				Good cuttings recovery.
680	Slight increase in coarse sand content.		680		
					Very fast drilling rate.
700			700	3-18	SAMPLED AT 700'
					Adding polymer.
720	Increase in coarse sand and gravel content.		720		
740			740		No recovery of cuttings.
					From 757 to 767' very slow penetration.
760	Clay		760		
	Clean fine sand			3-19	SAMPLED AT 767'
780			780		Increase in drilling resistance, slow penetration.
	Clay				
800			800		
	Sand: medium to coarse-grained				From 815 to 818' increase in drilling penetration rate.
820	Clay		820		
840			840		No returns, no samples to total depth.
860			860		
880			880		
900			900		
920			920		
940			940		
	Total Depth 947 ft.				
960			960		

FIELD LOG OF BORING NO. MW-3 SHEET 3 OF 3

Woodward-Clyde Consultants

PROJECT NAME Thousand Springs Energy Project NO. 90270B

BORING LOCATION MW -4 NW 1/4, NW 1/4, Section 21, T41N, R65E		ELEVATION AND DATUM 5491 ft., MSL (Ground Surface)	
DRILLING AGENCY R.D. Reynolds Drilling	DRILLER R. Reynolds	DATE STARTED 7/14/88 DATE FINISHED 7/15/88	
DRILLING EQUIPMENT Schram Rota Drill		COMPLETION DEPTH 85' BGS	SAMPLER Drill Cuttings
DRILLING METHOD Air Rotary	DRILL BIT 6" tri-cone roller bit	NO. OF SAMPLES DIST. 22	UNDIST. 0
SIZE AND TYPE OF CASING 2" Schedule 80 PVC		WATER LEVEL FIRST	COMPL. 24 HRS.

TYPE OF PERFORATION 2" Schedule 80 Slotted (0.020") PVC	FROM 75 TO 85	LOGGED BY: D. Jorgenson	CHECKED BY: J. Strandberg
SIZE AND TYPE OF PACK Fine sand Wadsworth Gravel	FROM 60 TO 65 FROM 65 TO 95		
TYPE OF SEAL NO. 1 Bentonite Bentonite and Gravel	FROM 55 TO 60 FROM 95 TO 100 FROM 100 TO 390		
NO. 2 Cement - Grout	FROM 0 TO 55		

DEPTH (feet)	LITHOLOGIC DESCRIPTION	Well Completion Diagram	DEPTH (feet)	SAMPLES	REMARKS (Drill Rate, Fluid Loss, Odor, etc.)
	sandy silt: lt. brown, fine to coarse-grained with gravels			4-1	Surface sample
	Becoming silty sand			4-2	Alluvium with some colluvium
20	gravelly sand: subangular to subrounded		20	4-3	Becoming wet
	Becoming clayey sand				
40	Sand: fine to coarse-grained with minor silt and gravel		40	4-4	Water enters Hard drilling @ 45'
	limestone: hard, lt. brown, argillaceous			4-5	Bedrock, weathered - strong reaction with HCl, samples consist of limestone fragments and chips, broken up by the tri-cone bit.
60			60	4-6	
	thin sand and gravel layers			4-7	
80			80	4-8	flow ~ 25 - 30 GPM since 40'
				4-9	
100			100	4-10	Flow increasing
	@ ~110' - sandy layer			4-11	
120			120		
				4-12	
140			140	4-13	Bedrock
	limestone: hard, lt. brown, argillaceous				
160			160		
	@ ~ 170 Thin, sand seams			4-14	
180	Becoming clayey		180		
				4-15	
200			200		
	sand and gravel: thin bed, sub-rounded			4-16	
220			220		
	sand and gravel:coarse, interlayered		240		Increase in flow to ~ 50 GPM
240				4-17	
260			260		
	sand and gravel: thin bed				
280			280		

FIELD LOG OF BORING NO. MW-4 SHEET 1 OF 2

Woodward-Clyde Consultants

PROJECT NAME Thousand Springs Energy Project NO. 90270B

DEPTH (feet)	LITHOLOGIC DESCRIPTION	Well Completion Diagram	DEPTH (feet)	SAMPLES	REMARKS (Drill Rate, Fluid Loss, Odor, etc.)
	limestone: hard, lt. brown, argillaceous			4-18	
300			300	4-19	
320			320	4-20	
340			340	4-21	
360			360	4-22	@ 370' water turns dark brown
380	sandy clay to claystone: lt. to dark brown, hard		380		Drilling is slowed due to clay, adding foam
	Total Depth 390 ft.				No samples due to foam, traces of clay on bit upon completion of trip out.
400			400		
420			420		
440			440		
460			460		
480			480		
500			500		
520			520		
540			540		
560			560		
580			580		
600			600		
620			620		
640			640		

FIELD LOG OF BORING NO. MW-4 SHEET 2 OF 2

Woodward-Clyde Consultants

PROJECT NAME Thousand Springs Energy Project NO. 90270B

BORING LOCATION MW-5 NE 1/4,NW1/4,NW 1/4, Section27, T39N,R65E		ELEVATION AND DATUM 5927 ft., MSL (ground surface)	
DRILLING AGENCY R. D. Reynolds Drilling	DRILLER R. Reynolds	DATE STARTED 7/20/88 DATE FINISHED 7/21/88	
DRILLING EQUIPMENT Schram Rota Drill		COMPLETION DEPTH N/A	SAMPLER Cuttings
DRILLING METHOD Air Rotary	DRILL BIT 6" tri-cone roller bit	NO. OF SAMPLES DIST. 15	UNDIST. 0
SIZE AND TYPE OF CASING NONE		WATER LEVEL FIRST	COMPL. - 24 HRS.
TYPE OF PERFORATION NONE	FROM TO	LOGGED BY: J.R. Raymond	CHECKED BY: J. Strandberg
SIZE AND TYPE OF PACK NONE	FROM TO		
TYPE OF SEAL NO. 1 Bentonite Backfill	FROM 230 TO 286		
NO. 2 Grout Backfill	FROM 0 TO 230		

DEPTH (feet)	LITHOLOGIC DESCRIPTION	Well Completion Diagram	DEPTH (feet)	SAMPLES	REMARKS (Drill Rate, Fluid Loss, Odor, etc.)
20	Limey shaley rubble: contains angular, multicolored rock fragments to 1" some sand, silt and clay. Rock fragments are mainly siliceous, some limestone fragments, some chert? or chalcedony?, some fragments have caliche or calcite coating.		20	5-1	
				5-2	
40	sand and silt and mud/siltstone		40		
	Clay layer			5-3	
60			60		
	Rock or boulders			5-4	
80	gravel: sub- angular to sub- rounded		80		
				5-5	
100			100		Very small amount of water at 102.5'
				5-6	
120	Rock or boulder		120		
				5-7	No additional water
140			140		
				5-8	
160			160		
				5-9	
180	Clay: brownish-orange		180		
	Clay: contains minor angular gravels, chert? fragments			5-10 & 5-10A	
200			200		
				5-11	
220	Clay: minor coarse-grained sand, few large angular fragments. Clay color changes from brown/orange to gray.		220		
	Clay diminishing; more coarse sand to fine gravel; siltstone/mudstone: gray, no reaction with HCl.			5-12	
240			240		
					← 5-13
260	limestone: gray ,"bedrock"? some angular rock fragments (carried down?)		260	5-14	Limestone probably fractured and weathered
	sand/gravel (carried down?)			5-15	No additional water encountered
280	TOTAL DEPTH 286'		280		

FIELD LOG OF BORING NO. MW-5 SHEET 1 OF 1

Woodward-Clyde Consultants

PROJECT NAME Thousand Springs Energy Project NO. 90270 B

BORING LOCATION MW -6 SW1/4, SE1/4, Section 19, T42N, R66E		ELEVATION AND DATUM 5378 ft. MSL (ground surface)	
DRILLING AGENCY R.D. Reynolds Drilling	DRILLER R. Reynolds	DATE STARTED 7/26/88 DATE FINISHED 7/28/88	
DRILLING EQUIPMENT Schram Rota Drill		COMPLETION DEPTH	SAMPLER Drill Cuttings
DRILLING METHOD Air Rotary	DRILL BIT 6" drag bit 6" tungsten carbide insert bit	NO. OF SAMPLES DIST. 39	UNDIST. 0
SIZE AND TYPE OF CASING None		WATER LEVEL FIRST —	COMPL. — 24 HRS. —
TYPE OF PERFORATION None	FROM TO	LOGGED BY: J.R. Raymond	CHECKED BY: J. Strandberg
SIZE AND TYPE OF PACK None	FROM TO		
TYPE OF SEAL NO. 1 Grout to surface	FROM 0 TO 526		
TYPE OF SEAL NO. 2	FROM TO		

DEPTH (feet)	LITHOLOGIC DESCRIPTION	Well Completion Diagram	DEPTH (feet)	SAMPLES	REMARKS (Drill Rate, Fluid Loss, Odor, etc.)
	aluvium: surficial sand, silt and angular gravel			6-1	
	Mixed angular rock fragments, mostly calcareous with some siliceous rocks.			6-2	
20	Angular rock fragments broken by drill bit. Minor amounts of silt and sand.		20	6-3	At 20' well producing ~1 gpm
	Smaller rock fragments, some darker colored, mostly limey material			6-4	
40	clay; angular rock fragments: mostly limestone		40	6-5	
				6-6	Limestone "bedrock" at 55'
60	Limestone: fractured and broken		60	6-7	
	Smaller limestone fragments (less broken by drill) may indicate less fracturing. Material is not highly indurated. Other rock fragments may be carried from above.			6-8	
80			80	6-9	
	Clay; limestone fragments			6-10	
100	Limestone; little or no clay		100	6-11	
				6-12	
120	Limestone: dark gray, drill cuttings consist of medium-sized angular fragments		120	6-13	
				6-14	
140			140	6-15	
				6-16	
160	As above		160	6-17	
	Limestone: more indurated, bit is chattering, drill cuttings are broken into smaller fragments			6-18	
180			180	6-19	Hole continues to produce ~1 gpm
				6-20	
200			200	6-21	
				6-22	
220			220	6-23	
				6-24	Hole producing ~3 gpm
240	A few lighter colored mudstone/siltstone fragments appearing		240	6-25	
				6-26	
260			260	6-27	
280			280		

BORING LOG OF BORING NO. MW-6 SHEET 1 OF 2

DEPTH (feet)	LITHOLOGIC DESCRIPTION	Well Completion Diagram	DEPTH (feet)	SAMPLES	REMARKS (Drill Rate, Fluid Loss, Odor, etc.)
300	Some limestone fragments show banding and layering		300	6-28	Hole producing 3-5 gpm
				6-29	
				6-30	
320	Basalt: black, mainly aphanitic, some material may be sloughed from above		320	6-31	Hard drilling
				6-32	Changed to 6" tungsten carbide insert bit
340	Cannot detect or distinguish between discrete basalt flows if present		340	6-33	
				6-34	
360			360	6-35	
				6-36	
380	Few pieces of quartzite and some zeolite inclusions in the basalt matrix		380	6-37	
	Some green colored weathered rock fragments			6-38	Hole making 3-5 gpm
400	Basalt: harder, fragments are smaller, some gray colored rock fragments		400	6-39	← 6-39
	Pyrite crystals present				
420			420		
440	Basalt to total depth		440		
460			460		
480			480		
500			500		
520	Total depth 526 ft.		520		
540			540		
560			560		
580			580		
600			600		
620			620		
640			640		

BORING LOG OF BORING NO. MW-6 SHEET 1 OF 2

Woodward-Clyde Consultants

PROJECT NAME Thousand Springs Energy Project NO. 90270B

BORING LOCATION MW-7 NE 1/4, SW1/4, Section 21, T41N, R66E		ELEVATION AND DATUM 5784 ft. MSL (ground surface)	
DRILLING AGENCY R. D. Reynolds Drilling	DRILLER R. Reynolds	DATE STARTED 7/25/88 DATE FINISHED 7/25/88	
DRILLING EQUIPMENT Schram Rota Drill		COMPLETION DEPTH	SAMPLER cuttings
DRILLING METHOD Air Rotary	DRILL BIT 6" drag bit	NO. OF SAMPLES DIST. 13	UNDIST. 0
SIZE AND TYPE OF CASING None		WATER LEVEL FIRST	COMPL. 24 HRS.
TYPE OF PERFORATION None	FROM TO	LOGGED BY: J.R. Raymond	CHECKED BY: K. Teague
SIZE AND TYPE OF PACK None	FROM TO		
TYPE OF SEAL NO. 1 Cement Grout	FROM 0 TO 160		
TYPE OF SEAL NO. 2	FROM TO		

DEPTH (feet)	LITHOLOGIC DESCRIPTION	Well Completion Diagram	DEPTH (feet)	SAMPLES	REMARKS (Drill Rate, Fluid Loss, Odor, etc.)
0	alluvium: surficial sand, silt and angular gravel		0	7-1	
	3/4 " gravels (angular, multicolored) rock fragments siliceous and carbonaceous				
20	Clay: brown, soft. Gravel: mixed with sand and clay Brown clay: minor sand, silt and gravel		20	7-2	
				7-3	
40			40	7-4	
				7-5	Limestone "bedrock" at 65' BGS
60			60	7-6	
	Color change in drill cuttings: from brown to gray; gray limestone fragments			7-7	
80			80	7-8	
				7-9	
100	Limestone: minor clay; sand (dragged down?)		100	7-10	
				7-11	
120	Limestone: "bedrock"? continues, harder		120	7-12	
140			140	7-13	
	Black colored limestone seam or stringer at 150' depth				
160	Total Depth 160'		160		Total Depth 160' BGS No Water
180			180		
200			200		
220			220		
240			240		
260			260		
280			280		

BORING LOG OF BORING NO. MW-7 SHEET 1 OF 1

Woodward-Clyde Consultants

PROJECT NAME Thousand Springs Energy Project NO. 90270B

BORING LOCATION MW-12 SW1/4, SW1/4, Section 31, T41N, R66E		ELEVATION AND DATUM 5594 ft. MSL (ground surface)	
DRILLING AGENCY R. D. Reynolds Drilling	DRILLER B. Miller	DATE STARTED 7/8/88 DATE FINISHED 7/16/88	
DRILLING EQUIPMENT Schram Rota Drill		COMPLETION DEPTH 330.5 ft	SAMPLER cuttings
DRILLING METHOD Air and Mud Rotary	DRILL BIT 10" tri-cone roller bit 6-1/4" tri-cone roller bit	NO. OF SAMPLES DIST. 23	UNDIST. 0
SIZE AND TYPE OF CASING 2" Schedule 80 PVC 1-1/4" Schedule 40 PVC		WATER LEVEL FIRST	COMPL. 24 HRS.
TYPE OF PERFORATION 2" Schedule 80 slotted (0.020) PVC 1-1/4" Schedule 40 saw-cut PVC	FROM 280.5 TO 300.5 FROM 130.0 TO 150.0	LOGGED BY: M. Castellanos	CHECKED BY: J. Strandberg
SIZE AND TYPE OF PACK Fine sand Wadsworth Gravel	FROM 260.0 TO 270.0 FROM 110 TO 160 FROM 270 TO 330		
TYPE OF SEAL NO. 1 Cement Grout	FROM 0.0 TO 100.0		
NO. 2 Bentonite Bentonite and gravel	FROM 100 TO 110 FROM 250 TO 260 FROM 160 TO 170 FROM 310 TO 330 FROM 170 TO 250 FROM 330 TO 600		

DEPTH (feet)	LITHOLOGIC DESCRIPTION
0	Soil horizon with assorted gravels
	Sand: buff to yellowish-gray, fine-grained with minor coarse-grained sand, sub-rounded to sub-angular, moderately sorted, moderately indurated, calcite chips present
40	Gravelly sand: fine to coarse grained, gravels to 10 mm, green (epidote?) red (jasper), brown (volcanic), black(hornfels?)
60	As above
120	Gravelly sand: poorly sorted, gravel to 20 mm, 30% sub-angular; sand: fine to coarse grained, trace of calcite
160	As above
240	Gravelly sand: unconsolidated, poorly sorted, fine to coarse grained; minor silt; minor gravel (~2%), sub-angular
260	Sand: fine to coarse grained, minor gravel(~3%), sub-angular to sub-rounded, trace of carbonate chips

Well Completion Diagram: 2" PVC; 1-1/4" PVC

DEPTH (feet)	SAMPLES	REMARKS (Drill Rate, Fluid Loss, Odor, etc.)
0	12-1	Air rotary drilling
	12-2	
	12-3	
20	12-4	
	12-5	
	12-6	
40		Convert to mud rotary
80	12-7	
	12-8	
120	12-9	Water possibly encountered
	12-10	
160		Water definately encountered
200	12-11	
220	12-11x	
240	12-12	
260	12-13	
280		

BORING LOG OF BORING NO. MW-12 SHEET 1 OF 2

DEPTH (feet)	LITHOLOGIC DESCRIPTION
	Sand: fine to coarse grained, same as above.
300	Gravelly Sand: ~ 80% medium grained, 10 % coarse grained, 5% fine grained; sand; gravel: subangular.
320	
340	Coarse Sand : with gravels, subangular, 4% sub-rounded, limestone chips, coarse to very coarse sand, finer grained sediment lost in washing.
360	Clayey Gravelly Sand
380	Sand: medium to coarse-grained, finer grained sediment washed out, trace of silt and clay
400	Clay: interbedded with silty clays, clay horizons of variable lateral thickness slight increase in carbonate chip content could be carried downward from above
420	Clayey Silty Sand: trace of white clay, carbonate not present, sands fine to coarse grained, possible thin interbedded sand and clay.
440	
460	As above
480	Clay : with minor sand.
500	Silty Clay: minor gravel and coarse sand.
	Silty Clay: increasing sand and gravel content.
520	Silty Clay: increasing sand content: fine to coarse grained, subangular, ~ 30% silty clay
540	From 540' to 560' no drill cuttings returned, lost circulation.
560	Silty Sand: trace of clay, fine to medium-grained sand; silt ~ 30%; no gravel
580	
600	Clayey Silty Sand: abundant clay.
	Total Depth 601 ft.
620	
640	

Well Completion Diagram

DEPTH (feet)	SAMPLES	REMARKS (Drill Rate, Fluid Loss, Odor, etc.)
300	12-14	
320		
340	12-15	
360	12-16	
	12-17	
380		
400	12-18	
	12-19	
420		
440		
460		
	12-20	
480		485' to 490' drilling very slow
500		@500' slow drilling
	12-21	@510' drilling rate increase
520		
540		no returns lost circulation
		hole caving slighty above the bit.
560	12-22	
580		
	12-23	
600		
620		
640		

BORING LOG OF BORING NO. MW-12 SHEET 1 OF 2

Woodward-Clyde Consultants

PROJECT NAME Thousand Springs Energy Project NO. 90270B

BORING LOCATION MW-16 NW1/4, NE1/4, Section 8, T40N, R67E		ELEVATION AND DATUM 5750 ft. MSL (ground surface)	
DRILLING AGENCY R.D. Reynolds Drilling	DRILLER R. Reynolds	DATE STARTED 11/15/88 DATE FINISHED 12/2/88	
DRILLING EQUIPMENT Bucyrus Erie Cable Tool		COMPLETION DEPTH 320 ft.	SAMPLER
DRILLING METHOD Cable tool	DRILL BIT	NO. OF SAMPLES DIST. 60	UNDIST.
SIZE AND TYPE OF CASING 2" SCH 80 PVC		WATER LEVEL FIRST	COMPL. 24 HRS.
TYPE OF PERFORATION 2" SCH 80 PVC 0.020" slot	FROM 300 TO 320	LOGGED BY: H. Merrell	CHECKED BY: K. Teague
SIZE AND TYPE OF PACK Wadsworth Gravel	FROM 50 TO 320		
TYPE OF SEAL NO. 1 Bentonite Cement	FROM 0 TO 50		
NO. 2 Backfill: drill cuttings	FROM 320 TO 600		

DEPTH (feet)	LITHOLOGIC DESCRIPTION
	Surface to 5 ft- soil, tan silt and clay, angular rock fragments, plant roots
25	
	As above; minor fine-grained sand
50	As above, minor very coarse-grained sand: sub-angular
	Clay: lt. tan, soft, gummy; volcanic tuff: dk. gray, very fine-grained, fissile, exhibits bedding <1mm thick
75	
100	Volcanic tuff: dk. gray, fine to very fine-grained, very thin bedded (< 0.1 to 0.3 mm) cuttings come to surface as 1/8" to 1/4" angular to sub-angular fragments; minor clay: dk. gray, soft, gummy, plastic
125	
	As above; cuttings at surface fine grained sand-sized
150	
175	As above; cuttings at surface 1/4" to 1/2", minor clay: lt. gray, soft, gummy
200	
225	As above, cuttings at surface ~1/2", minor clay
250	As above, cuttings at surface ~1/2", minor clay
275	Clay: lt. gray, soft , gummy: minor volcanic tuff as above
	Volcanic tuff: dk. gray, fine to very fine-grained, very thin bedded (< 0.1 to 0.3 mm) cuttings come to surface as 1/8" to 1/4" angular to sub-angular fragments; minor clay: dk. gray, soft, gummy, plastic
300	
325	
350	Volcanic tuff: as above, no clay

Well Completion Diagram

DEPTH (feet)	SAMPLES	REMARKS (Drill Rate, Fluid Loss, Odor, etc.)
	1	
	2	
25	3	
	4	
	5	
50	6	
	7	
75	8	
	9	
	10	
100	11	
	12	
125	13	
	14	
	15	
150	16	
	17	
175	18	
	19	
	20	
200	21	
	22	
225	23	
	24	
	25	
250	26	
	27	
275	28	
	29	
	30	
300	31	
	32	
325	33	
	34	
	35	
350		

FIELD LOG OF BORING NO. MW-16 SHEET 1 OF 2

PROJECT NAME Thousand Springs Energy Project NO. 90270B

LITHOLOGIC DESCRIPTION	Well Completion Diagram	DEPTH (feet)	SAMPLES	REMARKS (Drill Rate, Fluid Loss, Odor, etc.)
Clay: dk. gray, soft, gummy; minor volc. tuff as above		375	36, 37, 38, 39, 40	
Volcanic tuff: dk. gray, fine to very fine-grained, very thin bedded (< 0.1 to 0.3 mm) cuttings come to surface as 1/4" to 1/2" angular to sub-angular fragments; minor clay: dk. gray, soft, gummy, plastic		400	41, 42	
As above		425	43, 44	
		450	45, 46, 47	
		475	48, 49	
As above, less clay		500	50, 51	
As above; cuttings consist of sub-angular silicic fragments		525	52, 53, 54	
Volcanic tuff: dk. gray, fine to very fine-grained, very thin bedded (< 0.1 to 0.3 mm) cuttings come to surface as 1/4" to 1/2" angular to sub-angular fragments; minor chert: white, translucent		550	55, 56, 57	
As above		575	58, 59	
As above — Total Depth 600 ft.		600	60	
		625		
		650		
		675		
		700		
		725		
		750		
		775		
		800		

FIELD LOG OF BORING NO. MW-16 SHEET 2 OF 2

Woodward-Clyde Consultants

PROJECT NAME Thousand Springs Energy Project NO. 90270B

BORING LOCATION MW -17 SE 1/4, NE 1/4, Section 35, T41N, R65E		ELEVATION AND DATUM 5512 ft. MSL (ground surface)	
DRILLING AGENCY R.D. Reynolds Drilling	DRILLER R. Boley	DATE STARTED 1/21/89 DATE FINISHED 2/13/89	
DRILLING EQUIPMENT Bucyrus-Erie Cable Tool Rig		COMPLETION DEPTH 260 ft.	SAMPLER
DRILLING METHOD Cable Tool	DRILL BIT 6" hardfaced chisel bit	NO. OF SAMPLES / DIST.	UNDIST.
SIZE AND TYPE OF CASING 2" Schedule 80 PVC		WATER LEVEL / FIRST	COMPL. / 24 HRS.
TYPE OF PERFORATION 2" Schedule 80 Slotted (0.020") PVC	FROM 230 TO 250	LOGGED BY: R. Boley	CHECKED BY: K. Teague
SIZE AND TYPE OF PACK Wadsworth Gravel	FROM 60 TO 260 FROM 300 TO 650		
TYPE OF SEAL NO. 1 Bentonite and Gravel	FROM 260 TO 300		
TYPE OF SEAL NO. 2 Cement - Grout	FROM 0 TO 60		

DEPTH (feet)	LITHOLOGIC DESCRIPTION	Well Completion Diagram	DEPTH (feet)	SAMPLES	REMARKS (Drill Rate, Fluid Loss, Odor, etc.)
25	0 to 5 ft: Clay and gravel 5 to 20 ft: Consolidated sand and gravel 20 to 40 ft: Consolidated fine to coarse gravel		25		
50	40 to 60 ft: Soft clay and fane gravel		50		
75	60 to 70 ft: Consolidated gravel 70 to 80 ft: Coarse gravel 80 to 100 ft: Interbedded brown sand and clay		75		70 to 80 ft: Water encountered
100	100 to 140 ft: Semi-consolidated gravel and sand		100		
125			125		
150	140 to 190 ft: Gravel and sand, layers of clay		150		
175			175		
200	190 to 215 ft: Brown sand and clay		200		
225	215 to 220 ft: Gravel- large, unconsolidated 220 to 225 ft: Gravel and sand 225 to 230 ft: Consolidated gravel 230 to 240 ft: Consolidated sand and clay 240 to 283 ft: Very soft sand and clay		225		
250			250		
275	283 to 290 ft: Consolidated gravel 290 to 410 ft: Sticky brown clay		275		
300			300		
325			325		
350			350		

FIELD LOG OF BORING NO. MW-17 SHEET 1 OF 2

DEPTH (feet)	LITHOLOGIC DESCRIPTION	Well Completion Diagram	DEPTH (feet)	SAMPLES	REMARKS (Drill Rate, Fluid Loss, Odor, etc.)
375			375		
400	410 to 414 ft: Hard, consolidated gravel 414 to 474 ft: Sticky clay w/ thin gravel layers		400		
425			425		
450			450		
475	474 to 480 ft: Hard consolidated gravel 480 to 500 ft: Tan to brown clay		475		
500	500 to 502 ft: Hard consolidated gravel 502 to 650 ft: sticky brown clay		500		
525			525		
550			550		
575			575		
600			600		
625			625		
650	Total Depth 650 ft.		650		
675			675		
700			700		
725			725		
750			750		
775			775		
800			800		

FIELD LOG OF BORING NO. MW-17 SHEET 2 OF 2

Woodward-Clyde Consultants

PROJECT NAME Thousand Springs Energy Project NO. 90270 B

BORING LOCATION TW -1 SE1/4, SE1/4, Section 35, T42N, R65E		ELEVATION AND DATUM 5386 ft. MSL (ground surface)	
DRILLING AGENCY R.D. Reynolds Drilling	DRILLER R. Reynolds	DATE STARTED 9/13/88 DATE FINISHED 9/15/88	
DRILLING EQUIPMENT Schram Rota Drill		COMPLETION DEPTH 315 ft	SAMPLER Drill Cuttings
DRILLING METHOD Air Rotary w/ foam	DRILL BIT 9-7/8" tri-cone roller bit	NO. OF SAMPLES DIST.	UNDIST.
SIZE AND TYPE OF CASING 6" SCH. 40 steel		WATER LEVEL FIRST —	COMPL. — / 24 HRS. —
TYPE OF PERFORATION Factory wirewound 0.050 slot	SEE COMPLETION GRAPHIC	LOGGED BY: H. Merrell	CHECKED BY: K. Teague
SIZE AND TYPE OF PACK Wadsworth gravel	FROM 50 TO 330		
TYPE OF SEAL NO. 1 Cement grout	FROM 0 TO 50		
NO. 2	FROM TO		

DEPTH (feet)	LITHOLOGIC DESCRIPTION	Well Completion Diagram	DEPTH (feet)	SAMPLES No.	SAMPLES Time	REMARKS (Drill Rate, Fluid Loss, Odor, etc.)
0	Interbedded clay and gravel		0			1st water, very slight
25			25			
50	Sand: tan, fine to coarse grained, subangular to subrounded, poorly sorted		50			
75			75			
100			100			
125			125			water production steadily increasing with depth, good flow
150	as above: with trace of white clay, light purple quartz		150			
175			175			
200			200			
225	as above		225			
250			250			
275			275			
300	Shale, light blue-green		300			estimated 300-400 gpm water discharged while drilling
325	Total Depth 330 ft.		325			
350			350			

FIELD LOG OF BORING NO. TW-1 SHEET 1 OF 1

Woodward-Clyde Consultants

PROJECT NAME Thousand Springs Energy Project NO. 90270 B

BORING LOCATION TW-3 SW1/4, NW1/4, Section 5, T39N, R66E		ELEVATION AND DATUM Approx. 5710 ft. (MSL) Ground surface	
DRILLING AGENCY R.D. Reynolds Drilling	DRILLER B. Boley	DATE STARTED 10/27/88 DATE FINISHED 12/18/88	
DRILLING EQUIPMENT Bucyrus-Erie Cable Tool		COMPLETION DEPTH 410 ft.	SAMPLER
DRILLING METHOD Cable Tool	DRILL BIT Hardfaced Chisel	NO. OF SAMPLES DIST. None	UNDIST.
SIZE AND TYPE OF CASING 22" Nom. x .375wall, steel from +1 ft. to 50 ft. 12"Nom. x .250wall, steel from +3 ft. to 410 ft.		WATER LEVEL FIRST ---	COMPL. 192.5 ft. (BTOC) / 24 HRS. ---
TYPE OF PERFORATION Stainless Steel Well Screen 0.050" slot	FROM 200, 290, 360 TO 280, 360, 390	LOGGED BY: H. Merrell	CHECKED BY: J. Strandberg
SIZE AND TYPE OF PACK Colorado Silica Sand 8/16	FROM 160 TO 410		
TYPE OF SEAL NO. 1 Bentonite and gravel	FROM 157 TO 160		
TYPE OF SEAL NO. 2 Cement grout	FROM 0 TO 160		

DEPTH (feet)	LITHOLOGIC DESCRIPTION	Well Completion Diagram	DEPTH (feet)	SAMPLES No.	SAMPLES Time	REMARKS (Drill Rate, Fluid Loss, Odor, etc.)
0	0 to 74 ft: Gravel and tan clay		0			
20			20			
40			40			
60			60			
80	74 to 154 ft: Brown clay and gravel		80			
100			100			
120			120			
140			140			
160	154 to 158 ft: Gravel 158 to 218 ft: Brown sandy clay and gravel		160			
180			180			
200			200			
220	218 to 228 ft: Brown sandy clay 228 to 240 ft: Brown sandy clay and interbedded gravel, beds are <1 ft. thick		220			
240	240 to 253 ft: Brown sandy clay 253 to 255 ft. Gravel		240			
260	255 to 280 ft: Brown clay and interbedded gravel, beds are <1 ft. thick		260			
280	280 to 282 ft: Gravel		280			

FILED LOG OF BORING NO. TW-3 SHEET 1 OF 2

DEPTH (feet)	LITHOLOGIC DESCRIPTION	Well Completion Diagram	DEPTH (feet)	SAMPLES	REMARKS (Drill Rate, Fluid Loss, Odor, etc.)
	282 to 286 ft: Brown sandy clay 286 to 308 ft: Brown sandy clay with thin interbedded gravel				
300	308 to 318 ft: Gravel and brown sandy clay		300		
320	318 to 331 ft: Brown sandy clay		320		
	331 to 335 ft: Gravel				
340	335 to 345 ft: Brown sandy clay 345 to 358 ft: Brown clay and thin interbedded gravel		340		
360	358 to 360 ft: Gravel 360 to 415 ft: Brown clay, sticky, very little gravel		360		
380			380		
400			400		
420	Total Depth 415 ft.		420		
440			440		
460			460		
480			480		
500			500		
520			520		
540			540		
560			560		
580			580		
600			600		
620			620		
640			640		

FILED LOG OF BORING NO. TW-3 SHEET 2 OF 2

Woodward-Clyde Consultants

PROJECT NAME Thousand Springs Energy Project NO. 90270 B

BORING LOCATION TW-12 SW1/4, SW1/4, Section 31, T41N, R66E		ELEVATION AND DATUM 5595 ft. MSL (ground surface)	
DRILLING AGENCY R.D. Reynolds Drilling	DRILLER K. Scruggs	DATE STARTED 7/3/88 DATE FINISHED 8/12/88	
DRILLING EQUIPMENT Schram Rota Drill		COMPLETION DEPTH 370 ft	SAMPLER Drill Cuttings
DRILLING METHOD Air Rotary w/ foam Mud Rotary	DRILL BIT 9-7/8" tri-cone roller bit	NO. OF SAMPLES DIST.	UNDIST.
SIZE AND TYPE OF CASING 6" SCH. 40 steel		WATER LEVEL FIRST ---	COMPL. --- 24 HRS. ---
TYPE OF PERFORATION Factory wirewound 0.050 slot	FROM 170 to 270 280 to 310 330 to 360	LOGGED BY: H. Merrell	CHECKED BY: K. Teague
SIZE AND TYPE OF PACK Wadsworth gravel	FROM 50 TO 142 150 370		
TYPE OF SEAL NO. 1 Cement grout	FROM 0 TO 50		
NO. 2 Bentonite pellets	FROM 142 TO 150		

DEPTH (feet)	LITHOLOGIC DESCRIPTION	Well Completion Diagram	DEPTH (feet)	SAMPLES No.	SAMPLES Time	REMARKS (Drill Rate, Fluid Loss, Odor, etc.)
0	Gravelly soil horizon Sand: fine-grained, tan to yellowish gray, sub-angular to sub-rounded		0			Drilling with air
30			30			
60	Gravelly sand: fine to coarse-grained, sub-round to sub-angular, gravel to 10 mm- red, green, brown, black		60			
90			90			
120			120			Water at 115 ft.
150	Gravelly sand: as above, gravel to 20 mm, sub-angular, trace of calcite		150			Hole sloughing, convert to mud rotary
180			180			
210			210			
240	as above, trace of silt and less gravel		240			
270	Sand: fine to coarse-grained, trace of gravel, trace of carbonate fragments		270			
300			300			Lost circulation at 292 ft.
330	Gravelly sand: medium to coarse-grained, sub-angular gravel		330			
360	As above		360			
	Total Depth 370 ft.					
390			390			
420			420			

FIELD LOG OF BORING NO. TW-12 SHEET 1 OF 1

Woodward-Clyde Consultants

PROJECT NAME Thousand Springs Energy Project NO. 90270 B

BORING LOCATION TW-14 NE1/4, NW1/4, Section 24, T39N, R65E		ELEVATION AND DATUM 5531 ft. MSL (ground surface)	
DRILLING AGENCY R.D. Reynolds Drilling	DRILLER K. Scruggs	DATE STARTED 8/26/88 DATE FINISHED 9/6/88	
DRILLING EQUIPMENT Schram Rota Drill		COMPLETION DEPTH 488 ft	SAMPLER Drill Cuttings
DRILLING METHOD Air Rotary w/ foam	DRILL BIT 9-7/8" tri-cone roller bit	NO. OF SAMPLES DIST.	UNDIST.
SIZE AND TYPE OF CASING 6" SCH. 40 steel		WATER LEVEL FIRST ---	COMPL. — 24 HRS. ---
TYPE OF PERFORATION Factory wirewound 0.050 slot	FROM 388 TO 488	LOGGED BY: H. Merrell	CHECKED BY: K. Teague
SIZE AND TYPE OF PACK Wadsworth gravel Slough	FROM 300 TO 508 FROM 508 TO 600		
TYPE OF SEAL NO. 1 Cement grout	FROM 0 TO 90		
NO. 2 Mixture of gravel & sand	FROM 90 TO 300		

DEPTH (feet)	LITHOLOGIC DESCRIPTION	Well Completion Diagram	DEPTH (feet)	SAMPLES No.	SAMPLES Time	REMARKS (Drill Rate, Fluid Loss, Odor, etc.)
0	Clay: lt. tan, soft		0			Drilling with water & foam
25	Gravel: black & gray, pea-sized, minor clay		25			
50	Gravel: 1/4" to 1/2" Gravel: 1/4" to 3/4", minor sand		50			
75	As above; some sand present		75			
100			100			
125			125			
150			150			
175			175			
200			200			
225			225			
250	Gravel: 1/16" to 1/8", occaisional 1/2"		250			
275	Gravel: 1/8" to 1/2"		275			
300	Fine gravel		300			
325	Coarse gravel		325			Water encountered 330 ft.
350	Coarse gravel: sub-rounded, black & tan		350			

FIELD LOG OF BORING NO. TW-14 SHEET 1 OF 2

Woodward-Clyde Consultants

PROJECT NAME Thousand Springs Energy Project NO. 90270B

DEPTH (feet)	LITHOLOGIC DESCRIPTION	Well Completion Diagram	DEPTH (feet)	SAMPLES	REMARKS (Drill Rate, Fluid Loss, Odor, etc.)
400			400		Water production increasing gradually to strong flow.
425			425		
450	Medium to coarse gravel		450		
475	Coarse to medium gravel		475		
500	Medium gravel		500		
	Fine gravel				Borehole filled with slough 508 to 600 ft.
525			525		
	Gravel: fine to medium-grained; sand				
550	Gravel: fine to medium grained, sub-rounded; sand: lt. tan, fine to medium-grained		550		
575	Gravel: medium to coarse-grained, sub-rounded		575		
	Gravel: fine to medium-grained, sub-rounded; Sand: lt. tan, very fine to medium-grained, clay matrix				
600	Total Depth 600 ft.		600		
625			625		
650			650		
675			675		
700			700		
725			725		
750			750		
775			775		
800			800		
825			825		

FIELD LOG OF BORING NO. TW-14 SHEET 2 OF 2

Woodward-Clyde Consultants

PROJECT NAME Thousand Springs Energy Project NO. 90270 B

BORING LOCATION TW-15 NW1/4, SW1/4, Section 9, T39N, R66E		ELEVATION AND DATUM 5721 ft. MSL (ground surface)	
DRILLING AGENCY R.D. Reynolds Drilling	DRILLER R. Reynolds	DATE STARTED 8/17/88 DATE FINISHED 8/25/88	
DRILLING EQUIPMENT Schram Rota Drill		COMPLETION DEPTH	SAMPLER Drill Cuttings
DRILLING METHOD Air Rotary w/ foam	DRILL BIT 9-7/8" drag bit 9-7/8"tri-cone roller bit	NO. OF SAMPLES DIST.	UNDIST.
SIZE AND TYPE OF CASING 6" SCH. 40 steel		WATER LEVEL FIRST —	COMPL. — 24 HRS. —
TYPE OF PERFORATION Factory wirewound 0.050 slot	FROM 275 TO 395	LOGGED BY: H. Merrell	CHECKED BY: K. Teague
SIZE AND TYPE OF PACK Wadsworth gravel	FROM 70 TO 240 245 425		
TYPE OF SEAL NO. 1 Cement grout	FROM 0 TO 70		
NO. 2 Bentonite pellets	FROM 240 TO 245		

DEPTH (feet)	LITHOLOGIC DESCRIPTION	Well Completion Diagram	DEPTH (feet)	SAMPLES No.	SAMPLES Time	REMARKS (Drill Rate, Fluid Loss, Odor, etc.)
0	Clay: lt. tan, soft		0			Drilling with air & foam, 10" hole
25	Gravel: coarse, dark gray & black Gravel and clay		25			
50	Silty clay: lt. tan		50			
75	Clay: lt. tan & black; minor gravel		75			
100	Siltstone: lt. tan; gravel: fine-grained		100			
125	Clay: lt. tan; minor gravel		125			
150	Clay: lt. tan Silty Clay: lt. tan		150			
175			175			
200			200			
225	Clay: lt. tan		225			
250	Clay: lt. tan; sand, tan, fine-grained		250			
275	Gravel: black, tan, gray, pea-sized		275			Bore begins producing water
300	Sand: lt. brown-tan, fine to medium-grained		300			Water flow increasing
325	gravel: fine to medium-grained		325			
350	Sand: lt. gray, fine to coarse-grained, subrounded, well sorted, poorly cemented		350			

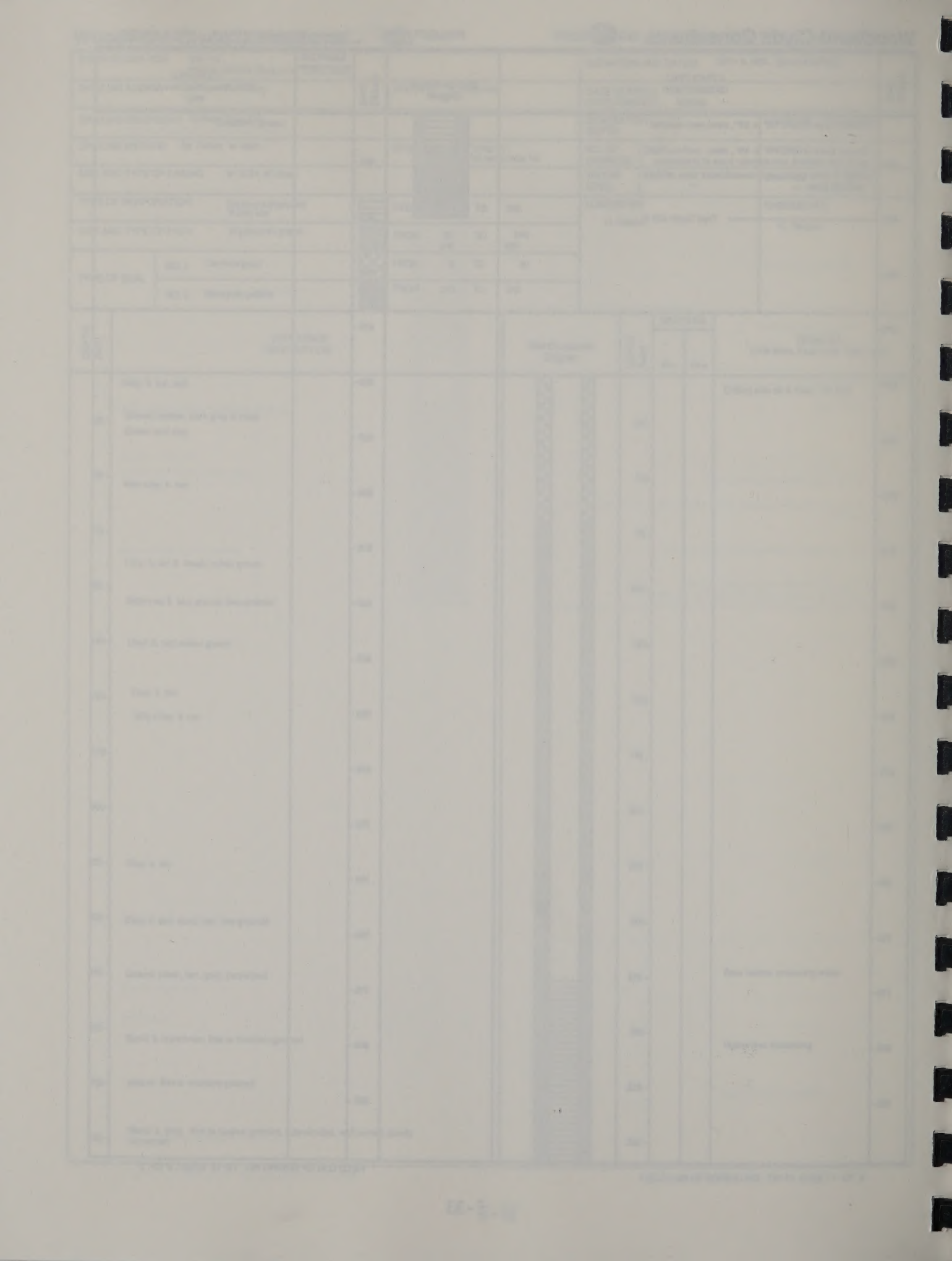
FIELD LOG OF BORING NO. TW-15 SHEET 1 OF 2

Woodward-Clyde Consultants

PROJECT NAME Thousand Springs Energy Project NO. 90270B

DEPTH (feet)	LITHOLOGIC DESCRIPTION	Well Completion Diagram	DEPTH (feet)	SAMPLES	REMARKS (Drill Rate, Fluid Loss, Odor, etc.)
400	Gravel: black-brown, 1/8" to 3/8", clean, well-rounded Gravel: black-brown, 1/8" to 3/8", clean, well-rounded, sand: fine-grained, sub-angular; trace of chalcedony Clay: lt. olive green, semi-consolidated; trace of black volcanic glass		400		Losing circulation
425	Total Depth 425 ft.		425		
450			450		
475			475		
500			500		
525			525		
550			550		
575			575		
600			600		
625			625		
650			650		
675			675		
700			700		
725			725		
750			750		
775			775		
800			800		
825			825		

FIELD LOG OF BORING NO. TW-15 SHEET 2 OF 2



APPENDIX F
AQUIFER TESTING PROCEDURES

APPENDIX F

AQUIFER TESTING PROCEDURES

1.0 INTRODUCTION

To assess the hydraulic characteristics of the unconsolidated sediments of the Toano Draw subbasin, six aquifer tests were performed, at test wells TW-1, TW-3, TW-12, TW-14, TW-15 and at an unused irrigation well located in SW1/4, NE1/4, Section 35, Township 41, Range 65 (41-65-35ad). Eight-hour constant rate pumping tests were performed at wells TW-3, TW-14, and TW-15. Forty-eight-hour constant rate pumping tests were performed at wells TW-1 and TW-12. A 13-day constant rate pumping test was performed at well 41-65-35ad. MW-series monitoring wells were installed within 100 feet of test wells TW-1, TW-3, TW-12, and well 41-65-35ad to provide additional water level data during drawdown and recovery periods of the aquifer tests.

2.0 FIELD TESTING PROTOCOL

2.1 Field Equipment

- 2 In-Situ Environmental Dataloggers, Model SE1000B
- 2 100 PSI x 400 foot In-Situ Pressure Transducer
- 1 50 PSI x 400 foot In-Situ Pressure Transducer
- 1 In-Situ Portable Field Printer
- 1 500 foot Solinst Water Level Indicator
- 1 300 foot Solinst Water Level Indicator
- 1 Rockwell In-line Turbine Flowmeter/Totalizer
- 1 digital chronometer
- 1 calibrated 5-gallon plastic bucket

- 1 diesel powered electric generator, w/ electrical wiring, fuses, and switchbox
- 1 1.5 HP electric submersible pump w/ electrical wiring and sufficient 2" std. galvanized pipe
- 1 2" threaded brass gate valve
- 1 100 foot vinyl discharge hose
- 1 9-5/8" O.D. 10-stage vertical line shaft turbine pump w/ all drive and pumping accessories

2.2 Background Depth to Water Level Measurements

For at least 3 days prior to conducting each aquifer test, depth to water levels, as measured below top of casing, was monitored in the test well and monitoring wells as available, to ensure that each well had fully recovered from previous well development activities.

3.0 8-HOUR AND 48-HOUR AQUIFER TESTS

The 8-hour and 48-hour tests were performed by setting the appropriate pump in the test well and all water level monitoring instruments in the test well and monitoring well(s). Proper functioning of the instruments was then checked. If necessary, a step drawdown test was conducted to determine an optimum pumping rate during the subsequent aquifer test. After the step drawdown tests, the wells were allowed to recover to static water levels, and then the test well was pumped at a constant rate for 8 or 48 hours. When the test period was complete, pumping was terminated and the wells were allowed to recover. Water levels in both the test well and monitoring well(s) were recorded by the datalogger during both pumping and recovery phases of the test. The operating procedure for each test will be described.

3.1 48-Hour Constant Rate Aquifer Test of Test Well TW-1

A step drawdown test and subsequent 48-hour constant rate aquifer test were performed on test well TW-1 during the period October 5-8, 1988. Depth to water measurements in TW-1 and its adjacent monitoring well MW-1 were taken 3 consecutive days in advance of the aquifer test. Pre-test measurements showed the water level in the wells to be under artesian conditions at about 0.5 feet above ground surface.

A 1.5 HP electric submersible pump with a 2" discharge line was set in the test well at a depth of 240 feet. Available drawdown was thus approximately 240 feet. Total depth of the well is 315 feet. The discharge line was directed away from the working area. A gate valve was installed in the discharge line upstream of the flow meter to control the pumping rate. Water pumped from the well was discharged through a flexible vinyl hose approximately 100 feet away into the dry bed of Thousand Springs Creek. Water level monitoring instruments were placed at the appropriate depths in both wells and checked for proper functioning. A Solinst water level indicator was lowered into each well for verification of water levels recorded by the datalogger during the test period. The datalogger was set to sample water levels at the following logarithmic rate:

Cycle	Elapsed Time	Log Sample Rate
1	0-2 sec.	0.033 sec.
2	2-60 sec.	0.166 sec.
3	60-120 sec.	0.833 sec.
4	2-10 min.	30 sec.
5	10-100 min.	2 min.
6	100-1000 min.	10 min.
7	1000-10000 min.	100 min.
8	10000-100000 min.	500 min.

When it was confirmed that all personnel, equipment, and instruments were prepared, the step drawdown test was started. The initial pumping rate of 30 GPM was maintained for 1 hour. Flow rate and volume were measured using the flow meter and chronometer and verified by inserting the calibrated bucket into the discharge stream and measuring the time required to fill it. Maximum drawdown at the end of the first step in TW-1 was 5.93 feet and in MW-1 was 2.21 feet. The pumping rate was increased to 60 GPM for the 2nd hour of the step test. Maximum drawdown at the end of the second step in TW-1 and MW-1 was 14.65 feet and 4.92 feet, respectively. For the third step of the test, the pumping rate was increased to 75 GPM and maintained for 1 hour. Maximum drawdown at the end of the third step in TW-1 was 20.30 feet and in MW-1 was 6.49 feet. The pump rate for the forth and final step of the test was increased to the maximum output of the pump, approximately 85 GPM. Maximum drawdown at the end of the 4th hour was 22.80 feet in TW-1 and 7.83 feet in MW-1. Pumping was then terminated and recovery was monitored by the datalogger. The well was left overnight to fully recover before starting the 48-hour test.

Because maximum drawdown in TW-1 was approximately 23 feet at maximum pump output and the available drawdown was 240 feet, it was decided that the optimum pumping rate would be 70 GPM for the 48-hour test. This would allow for adjusting the pumping rate to maintain the optimum rate while the pumping lift increased during the test.

After all water level monitoring instruments were reset and checked for proper functioning, and full recovery verified in both wells, the 48-hour constant rate aquifer test was started the morning of October 6, 1988. The well was pumped at a rate of 70 GPM for 48 hours. The pumping rate was checked hourly using the flow meter and chronometer and adjusted if needed. The pumping rate never varied more than 3 percent from the optimum. Electrical output of the generator, as well as fuel and oil levels of the diesel engine, were also checked hourly and maintained at safe operating levels. Water levels in both wells were sampled by the datalogger at the

logarithmic rate discussed earlier and verified using the Solinst water level indicators. Maximum drawdown in TW-1 and MW-1 was 21.91 feet and 8.87 feet, respectively. Pumping was terminated the morning of October 8, 1988. Recovery was then monitored in both wells until 90 percent recovery was achieved. Pumping and recovery data were printed and all instruments and equipment removed from the wells.

3.2 48-Hour Constant Rate Aquifer Test of Test Well TW-12

A step drawdown test and subsequent 48-hour constant rate aquifer test were performed on test well TW-12 during the period October 10-13, 1988. Depth to water measurements in TW-12 and its monitoring well, MW-12, were taken 3 consecutive days in advance of the aquifer test. Depth to water as measured below top of casing ranged from 125.22 feet to 125.35 feet for TW-12 and 124.90 to 125.07 feet for MW-12. Pre-test measurements were 124.23 feet and 124.90 feet for TW-12 and MW-12, respectively.

A 1.5 HP electric submersible pump with a 2" discharge line was set in the test well at a depth of 240 feet. Available drawdown was thus approximately 115 feet. Total depth of the well is 360 feet. The discharge line was directed away from the working area. A gate valve was installed in the discharge line upstream of the flow meter to control the pumping rate. Water pumped from the well was discharged through a flexible vinyl hose approximately 100 feet away into a small tributary of Toano Draw. Water level monitoring instruments were placed at the appropriate depths in both wells and checked for proper functioning. A Solinst water level indicator was lowered into each well for verification of water levels recorded by the datalogger during the test period. The datalogger was set to sample water levels at the logarithmic rate discussed earlier.

When it was confirmed that all personnel, equipment, and instruments were prepared, the step drawdown test was started. The initial pumping rate of 50 GPM was maintained for 68 minutes. Flow rate and volume were measured using the flow meter and chronometer and verified by inserting the

calibrated bucket into the discharge stream and measuring the time required to fill it. Maximum drawdown at the end of the first step in TW-12 was 5.95 feet. Drawdown was not measured in the monitoring well for this step test. The pumping rate for the second and last step of the test was increased to the maximum the pump could produce, 75 GPM. This rate was maintained for 67 minutes. Maximum drawdown at the end of the second step was 9.44 feet. Pumping was then terminated and the well allowed to recover overnight.

Because the maximum drawdown in TW-12 was approximately 9.5 feet and the available drawdown was 115 feet, it was decided that the optimum pumping rate for the 48-hour test would be 65 GPM. This would allow for increasing the pumping rate to maintain the optimum rate should well production diminish during the test.

After all water level monitoring instruments were reset and checked for proper functioning, and full recovery verified in both wells, the 48-hour constant rate aquifer test was started on the morning of October 11, 1988. The well was pumped at a rate of 65 GPM for 48 hours. The pumping rate was checked hourly using the flow meter and chronometer and adjusted if needed. The pumping rate never varied more than 3 percent from the optimum. Electrical output of the generator as well as fuel and oil levels of the diesel engine were also checked hourly and maintained to safe operating levels. Water levels in both wells were sampled by the datalogger at the logarithmic rate discussed earlier and verified using the Solinst sounders. Maximum drawdown in TW-12 and MW-12 was 8.05 feet and 2.19 feet, respectively. Pumping was terminated the morning of October 13, 1988. Recovery was then monitored in both wells until at least 90 percent recovery was achieved. Pumping and recovery data were printed and all instruments and equipment removed from the wells.

3.3 8-Hour Constant Rate Aquifer Test of Test Well TW-15

A complete step drawdown test of TW-15 was not considered necessary because the step tests performed previously had not exceeded the available drawdown. Given the greater depth of pumping (340 feet) requiring greater lift, it was decided that available drawdown in TW-15 would not be exceeded. However, prior to the 8-hour test, the well was pumped at the maximum sustainable rate for the given pumping depth to determine an optimum pumping rate. The well produced 67 GPM and the optimum pumping rate selected for the 8-hour test was 60 GPM.

An 8-hour constant rate aquifer test was performed on TW-15 October 14, 1988. Depth to water level measurements in TW-15 were taken 4 consecutive days in advance of the aquifer test. Depth to water measurements ranged from 211.85 feet to 212.01 feet. The pre-test depth to water was 211.79 feet. There is no MW-series monitoring well at this location.

A 1.5 HP electric submersible pump with a 2" discharge line was set in the test well at a depth of 340 feet. Available drawdown was thus approximately 128 feet. Total depth of the well is 400 feet. The discharge line was directed away from the working area. A gate valve was installed in the discharge line upstream of the flow meter to control the pumping rate. Water pumped from the well was discharged through a flexible vinyl hose approximately 100 feet away into a small tributary of Toano Draw. Water level monitoring instruments were placed at the appropriate depths in both wells and checked for proper functioning. A Solinst water level indicator was lowered into each well for verification of water levels recorded by the datalogger during the test period. The datalogger was set to sample water levels at the logarithmic rate discussed earlier.

When it was confirmed that all personnel, equipment, and instruments were prepared, the 8-hour aquifer test was started. The pumping rate of 60 GPM was maintained for 8 hours. The pumping rate and volume were measured using the flow meter and chronometer and verified by inserting the cal-

ibrated bucket into the discharge stream and measuring the time required to fill it. The pumping rate never varied by more than 1.5 percent from the optimum. Electrical output of the generator as well as fuel and oil levels of the diesel engine were also checked hourly and maintained to safe operating levels. Water levels were sampled by the datalogger at the logarithmic rate discussed earlier and verified using the Solinst water level indicator. Maximum drawdown in TW-15 was 2.03 feet. Pumping was terminated after 8 hours and recovery was then monitored by the datalogger until 90 percent recovery was achieved. Pumping and recovery data were printed and all instruments and equipment removed from the wells.

3.4 8-Hour Constant Rate Aquifer Test of Test Well TW-14

A complete step drawdown test of TW-14 was also not considered necessary for the reasons cited previously for TW-15. Given the depth of pumping (385 feet) and the capabilities of the pump, it was decided to pump the well at the maximum sustainable rate for the given pumping depth to determine an optimum pumping rate. The well produced 53 GPM and the optimum pumping rate selected for the 8-hour test was 45 GPM.

An 8-hour constant rate aquifer test was performed on TW-14 October 16, 1988. Depth to water level measurements in TW-14 were taken four consecutive days in advance of the aquifer test. Depth to water measurements ranged from 315.65 feet to 315.82 feet. The pre-test depth to water was 315.50 feet. There is no MW-series monitoring well at this location.

A 1.5 HP electric submersible pump with a 2" discharge line was set in the test well at a depth of 385 feet. Available drawdown was thus approximately 70 feet. Total depth of the well is 488 feet. The discharge line was directed away from the working area. A gate valve was installed in the discharge line upstream of the flow meter to control the pumping rate. Water pumped from the well was discharged through a flexible vinyl hose approximately 100 feet away into a small tributary of Toano Draw. Water level monitoring instruments were placed at the appropriate depths in the

well and checked for proper functioning. A Solinst water level indicator was lowered into the well for verification of water levels recorded by the datalogger during the test period. The datalogger was set to sample water levels at the logarithmic rate discussed earlier.

When it was confirmed that all personnel, equipment, and instruments were prepared, the 8-hour aquifer test was started. The pumping rate of 45 GPM was maintained for 8 hours. The pumping rate and volume were measured using the flow meter and chronometer and verified by inserting the calibrated bucket into the discharge stream and measuring the time required to fill it. The pumping rate never varied by more than 6.5 percent from the optimum. Electrical output of the generator as well as fuel and oil levels of the diesel engine were also checked hourly and maintained to safe operating levels. Water levels were sampled by the datalogger at the logarithmic rate discussed earlier and verified using the Solinst water level indicator. Maximum drawdown in TW-14 was 6.50 feet. Pumping was terminated after 8 hours and recovery was then monitored by the datalogger until at least 90 percent recovery was achieved. Pumping and recovery data were printed and all instruments and equipment removed from the wells.

3.5 8-Hour Constant Rate Aquifer Test of Test Well TW-3

A step drawdown test and subsequent 8-hour constant rate aquifer test were performed on test well TW-3 during the period December 19-21, 1988. Depth to water measurements in TW-3 and its monitoring well, MW-3, were taken five consecutive days in advance of the aquifer test. Depth to water, as measured below top of casing, ranged from 191.95 feet to 192.71 feet for TW-3 and 192.45 feet to 192.71 feet for MW-3. Pre-step test measurements were 191.95 feet and 192.71 feet for TW-3 and MW-3, respectively.

A 10-stage vertical line shaft turbine pump was placed in the test well. Pump intake depth was 360 feet. Available drawdown was thus 168 feet. Total depth of the well is 410 feet. A right-angle top drive was coupled to the pump drive shaft and 8" pump column. A 250 HP diesel engine

provided power to the top drive. An 8" O.D. x 10 FT discharge pipe was connected to the top drive and positioned so that water pumped from the well was discharged into a natural gulley that emptied into the dry stream channel of Toano Draw. A 4" orifice plate was placed at the end of the discharge pipe and a clear vinyl manometer tube was mounted 24" upstream of the orifice plate to measure pressure head within the discharge pipe. The clear vinyl manometer tube was fixed adjacent to a scale calibrated to indicate the pump rate in gallons per minute. The pump rate was controlled by increasing or decreasing the engine speed of the drive engine. Water level monitoring instruments were placed in both wells to the appropriate depth and checked for proper functioning. A Solinst water level indicator was lowered into MW-3 for verification of water levels recorded by the datalogger during the test period. An obstruction in TW-3 prevented lowering a water level indicator to water level. The datalogger was set to sample water levels at the logarithmic rate discussed previously.

When it was confirmed that all personnel, equipment, and instruments were prepared, the step drawdown test was started. The initial pumping rate of 100 GPM was maintained for 1 hour. Flow rate was measured using the manometer tube and calibrated scale. Maximum drawdown at the end of the first step in TW-3 was approximately 22 feet and 10 feet in MW-3. The pumping rate was increased to 200 GPM for the 2nd hour of the step test. Maximum drawdown at the end of the second step in TW-3 and MW-3 was 53 feet and 25 feet, respectively. Analysis of the data provided by the two steps predicted that the well could produce approximately 325 GPM with the available drawdown. For the 3rd and final hour of the step test, the pumping rate was increased to 330 GPM. After several minutes at this rate, well production began to decrease. The pump rate was reduced to 300 GPM. Drawdown continued to increase and the pump rate could not be maintained. At the end of the test drawdown in TW-3 was 124 feet and the pump rate was 280 GPM. Drawdown in MW-3 was 56 feet. The well was left overnight to fully recover before starting the 8-hour test. Analysis of the step test data indicated that an optimum pump rate for the 8-hour test would be approximately 250 GPM.

Depth to water levels immediately prior to the 8-hour test were 192.48 feet and 193.36 feet for TW-3 and MW-3, respectively. When it was confirmed that all personnel, equipment, and instruments were prepared, the 8-hour aquifer test was started. The pumping rate of 220-225 GPM was maintained for 8 hours. The pumping rate was measured using the manometer tube and calibrated scale. When the measured pump rate fell below 220 GPM, the engine speed of the drive engine was increased. The pumping rate was subject to brief (30 seconds or less) fluctuations of up to 260 GPM when this adjustment occurred. Water levels were sampled by the datalogger at the logarithmic rate discussed earlier and verified in MW-3 using the Solinst water level indicator. Maximum drawdown in TW-3 was 88 feet and 46 feet in MW-3. Pumping was terminated after 8 hours and recovery was then monitored by the datalogger until at least 90 percent recovery was achieved. Pumping and recovery data were printed and all instruments and equipment removed from the wells.

4.0 LONG TERM CONSTANT RATE AQUIFER TEST OF WELL 41-65-35ad

A 13-day constant rate aquifer test was performed on an unused irrigation well during the period February 16-March 1, 1989. Depth to water measurements in the monitoring wells 41-65-35bd and 40-65-2ab was taken 4 consecutive days in advance of the aquifer test. Depth to water as measured below top of casing ranged from 31.33 feet to 31.39 feet for well 41-65-35bd and 42.64 to 42.67 feet for well 40-65-2ab. A length of discharge pipe installed on the pumping well 41-65-35ad prevented measurement of depth to water previous to the test start. However, several depth to water measurements in well 41-65-35ad had been taken during the 2 months preceeding the test. These measurement indicated a static water level of approximately 47.60 feet. Depth to water measurements for MW-17 were taken only 1 day in advance of the test because the well was still being drilled and installed until that time. Depth to water in MW-17 was 49.86 feet immediately prior to the start of the test. Well 41-65-35ad is an

existing, certificated irrigation well. The long-term test utilized the existing installed vertical line-shaft turbine pump. A propane-powered six-cylinder engine was used to power the pump. A 2000-gallon propane tank supplied fuel to the engine. The well was pumped for several hours approximately 1 month prior to the commencement of the long-term test to determine its usefulness to such a test. The well has a total depth of 650 feet and is screened from 50 feet to 650 feet depth.

A 10" O.D. x 30 FT discharge pipe was connected to the discharge port on the top drive and positioned so that water pumped from the well was discharged into a natural gulley that emptied into the dry stream channel of Toano Draw. A 7" orifice plate was placed at the end of the discharge pipe and a clear vinyl manometer tube was mounted 24" upstream of the orifice plate to measure pressure head within the discharge pipe. The clear vinyl manometer tube was fixed adjacent to a scale calibrated to indicate the pump rate in gallons per minute. The pump rate was controlled by adjusting a governor which controlled the speed of the drive engine. Water level monitoring instruments were placed in monitoring wells MW-17 and 41-65-35bd to the appropriate depth and checked for proper functioning. Drawdown data was monitored in well 40-65-2ab using a Solinst sounder. The datalogger was set to sample water levels at the logarithmic rate discussed previously.

When it was confirmed that all personnel, equipment, and instruments were prepared, the long-term test was started February 16, 1989. A pumping rate of 900 GPM was maintained for approximately 13 days. The indicated flow rate never varied by more than +- 2 percemt. Flow rate and engine function were monitored and adjusted hourly, throughout the duration of the test . Water levels in MW-17 and 41-65-35bd were sampled by dataloggers. Water levels in well 40-65-2ab were taken using the solinst sounder 2 or 3 times daily. Pumping was terminated March 1, 1989. Maximum drawdown at the end of the test in MW-17 and 41-65-35bd was 23.5 feet and 2.3 feet, respectively. Drawdown in well 40-65-2ab was 0.9 feet. The construction

of the pumping well did not allow for monitoring drawdown. After terminating the test, the discharge pipe was removed from the pumping well as rapidly as possible to allow access for instruments to monitor recovery. Recovery was allowed to continue for approximately 5 days. All instruments were then removed and pumping and recovery data were printed.

APPENDIX G
WATER SAMPLING AND ANALYSIS PROCEDURES

G-1

TABLE OF CONTENTS

Section		Page
1.0	INTRODUCTION	1
2.0	SAMPLING PARAMETERS	2
3.0	GROUNDWATER SAMPLING	4
	3.1 Monitoring Well Locations	4
	3.2 Measurement of Static Water Levels	5
	3.3 Purging Standing Water from Wells	5
	3.4 Groundwater Sampling	7
	3.4.1 Preparation	7
	3.4.2 Groundwater Sampling Procedures	7
4.0	SURFACE WATER SAMPLING	12
	4.1 Surface Water Sampling Locations	13
	4.2 Surface Water Sampling	13
	4.2.1 Preparations	13
	4.2.2 Spring Water Sampling Procedures	13
5.0	SAMPLE HANDLING	16
	5.1 Sample Handling Procedures	16
	5.2 Chain-of-Custody Procedures	17
6.0	LABORATORY PROCEDURES	19
	6.1 Sample Bottle Preparation	19
	6.2 Sample Reception and Analysis	19
7.0	Quality Assurance/Quality Control (QA/QC)	20
	7.1 QA/QC Procedures for Field Work	20
	7.2 QA/QC Samples	20

LIST OF TABLES

Table

G-1 SAMPLING PARAMETERS AND RATIONALE

G-2 IDENTIFICATION OF WELLS TO BE SAMPLED AND SAMPLING PARAMETERS

G-3 SAMPLE BOTTLE ORDER OF FILLING, BOTTLE TYPE, PRESERVATIVES, AND FILTRATION REQUIREMENTS OF GROUNDWATER AND SURFACE WATER

G-4 IDENTIFICATION OF SPRINGS/SEEPS TO SAMPLE AND SAMPLING PARAMETERS

G-5 ANALYTICAL METHODS AND SAMPLE HOLDING TIME

LIST OF FIGURES

Figure

G-1 GROUNDWATER SAMPLING FORM

G-2 ALKALINITY TITRATION FORM

G-3 SURFACE WATER SAMPLING FORM

G-4 CHAIN-OF-CUSTODY RECORD

1.0
INTRODUCTION

The objectives of this Sampling and Analysis Plan are to designate the groundwater and surface water locations that were sampled and define the methods that were used for measuring, sampling, and analyzing water in the wells and springs in the vicinity of the proposed Thousand Springs power plant. This plan provides for background characterization of the water quality of the region. The background data will be used to evaluate the usefulness of the water to the plant and will be used to evaluate the effect of groundwater withdrawal on water quality. The water chemistry evaluation is also used to define areal and vertical trends in groundwater quality by preparing contour maps of selected dissolved constituents and it will be used to provide data on the origin and sources of the thermal waters and springs.

The following procedures were implemented for all groundwater and surface water sampling that was conducted during the hydrogeologic investigations at the site. The procedures were used for measurement and sampling, unless approval to deviate from this plan was obtained from the Project Manager or the Hydrogeology Task Leader.

2.0
SAMPLING PARAMETERS

Water samples collected from groundwater and surface water locations were analyzed for some or all of the parameters listed in Table G-1. Field measurements were made for parameters that change rapidly after sample collection and which cannot be preserved for laboratory analysis. These parameters are temperature, pH, specific conductance, and alkalinity. The temperature was measured because it may show that the water has been influenced by geothermal processes and the temperature must be known to make calculations of mineral equilibria. The pH of the water affects ion speciation and mineral equilibria. Specific conductance is a measure of the amount of dissolved constituents in the water and was used to compare with the analysis of individual elements for QA/QC purposes. The alkalinity of the water was measured to determine the amount of carbonate and bicarbonate in the water. In shallow groundwaters these constituents are generally the dominant anions.

Major cations (Ca, Mg, Na, and K) were measured in order to aid in classifying the various water types sampled and to be able to make mineral equilibria calculations. The silicon (Si) content of the water is an indicator of geothermal activity because of the higher solubility of silica (SiO_2) at elevated temperatures. Silica content may also be related to residence time of water in water-bearing rock. The major anions (Cl, SO_4, NO_3+NO_2, F) were also analyzed for classification purposes and mineral equilibria calculations. In addition, drinking water standards exist for these anions.

The trace/minor inorganics listed in Table G-1 were analyzed because they are indicators of water quality. Additionally, lithium and boron have been shown to be useful in understanding geothermal systems. The stable isotopes of hydrogen (H/D) and oxygen ($^{18}O/^{16}O$) were analyzed in a select number of wells and springs because these isotopes have been shown to be useful in determining the source of water (meteoric vs. juvenile) in geothermal systems. Tritium, the radioactive isotope of hydrogen, was used to determine if groundwater in the springs or wells is relatively young (less than 50 years since it equilibrated with the atmosphere). This may demonstrate the rate of groundwater recharge. The total dissolved solids level of the water was measured as another indicator of the usefulness of the water to the power plant and to compare this parameter with the individual measurements of major ion concentrations.

3.0
GROUNDWATER SAMPLING

Prior to operation of the power plant, monitoring wells were installed in the vicinity of the proposed plant and wellfield supplying the plant. The water levels in these monitoring wells and selected existing wells were measured to determine the gradient of the water table so that estimates of groundwater flow direction and velocity could be made. Water samples were collected and analyzed from these wells. The wells that were sampled are listed in this section and the procedures for conducting water level measurements, purging water from the well, and sampling the water are specified.

3.1 MONITORING WELL LOCATIONS

Depth to groundwater measurements were made and samples collected from selected newly-installed wells and selected existing wells. A preliminary list of wells that were monitored and their approximate locations are given in Table G-2. The locations of these monitoring wells are shown in Figure 5-1.

The existing wells monitored and sampled are located in areas not sampled by the new wells and in areas where the need for a more thorough understanding of groundwater characteristics was identified. The data from these wells will provide a regional characterization of the water chemistry. Well completion information including well depth and screened interval were available from the Nevada State Engineers office. One well (41-64-25bb) is located in the Thousand Springs Valley near the Winecup Ranch and one well (41-67-22bc) is located in Twentyone Mile Draw. One

well (41-66-33ac) is located in Fivemile Draw and the remaining wells (40-65-10ca, 40-65-24bd, 41-65-35ad) are located in Toano Draw near the proposed facility location.

3.2 MEASUREMENT OF STATIC WATER LEVELS

Static water levels were measured in each well prior to any other groundwater sampling activity. Measurements were performed for all wells in as short a time interval as was possible.

Water level measurements were performed with an electrical water level indicator (sounder). The condition of the sounder, including battery charge, physical integrity, and probe condition, were checked prior to commencing field work.

Pertinent descriptive information, including time of measurement and ambient weather conditions, was recorded on the groundwater sampling form (Figure G-1). Measurements of groundwater elevation and well depth were made to the nearest hundredth of an inch. The water level in feet above mean sea level was calculated by subtracting the depth to water from the elevation of the surveyed or estimated reference point for the well. Elevations for wells without a surveyed reference point were estimated from 7.5 minute USGS topographic quadrangles. Where possible, the total depth of the well was measured and compared with the depth listed on the boring log, if available.

3.3 PURGING STANDING WATER FROM WELLS

The chemistry of water standing in a well is not representative of aquifer conditions because the water equilibrates with atmospheric gases, may leach components from the casing material, and some dissolved constituents may adsorb onto the casing and be removed from solution. For this reason the standing water was removed from the well bore in order to

induce the movement of fresh groundwater into the well so that water representative of the groundwater could be collected for measurement and analysis.

Prior to commencing purging, the well was inspected for physical integrity. The date and time, weather conditions, and other pertinent data were recorded on the water sampling form.

Purging was accomplished using existing pumping apparatus or by lowering a submersible electric pump into the well. In some cases it was necessary to remove inoperable existing pump equipment to allow lowering of the sampling pump. The interior of the pump and discharge line were flushed during the purging operation and did not require special cleaning.

During purging, discharge rates and volumes were measured by periodically inserting a container of known volume into the discharge stream and recording the time required to fill it. Where this method was not practical, a portable flume or inline flowmeter was used to determine pumping rates. Pumping rate and volume were periodically recorded on the water sampling form.

At least three casing volumes of water were purged from each well. The total volume of water was recorded on the water sampling form. Samples were taken from the pump discharge line after three casing volumes had been removed. Several wells sampled were being operated for stock watering purposes. Arrangements were made with the ranch pump foreman to ensure several days of continuous pump operation so that samples obtained were representative of groundwater.

3.4 GROUNDWATER SAMPLING

3.4.1 Preparation

A preliminary list of wells that were sampled, their approximate location, and the parameters analyzed for each well are given in Table G-2. Bottle types, preservatives, and filtration requirements are provided in Table G-3. The sample bottles were labeled with the well identification, name of collector, date and time of collection, requested analyses, and any preservatives added to the water sample. Each suite of bottles were organized and labeled prior to commencing sampling. Each cooler in which sample bottles were stored was cleaned and dried prior to sampling.

3.4.2 Groundwater Sampling Procedures

Temperature, pH, and specific conductance measurements were performed in the field immediately before and after sample collection as a check on the stability of these chemical parameters during sampling. The specific conductance meter and pH meter were calibrated prior to each day's work in accordance with the manufacturers specifications. A plastic container cleansed with nonphosphatic laboratory grade detergent and thoroughly rinsed first with deionized water and then with water collected from the well was used to collect water for field measurement of temperature, pH, and specific conductance. After sampling of the well was complete, the plastic container was rinsed thoroughly with water collected from the well and a second set of temperature, pH, and specific conductance field measurements was performed. All results of the measurements were recorded on the water sampling form.

The order of filling the sample bottles is given in Table G-3. At most, four sample bottles were filled at a well. In order of filling, these bottles are 500-ml plastic bottle for analysis for major cations and trace/minor inorganics, 1000-ml plastic bottle for analysis of major anions and total dissolved solids (TDS), 1000-ml glass bottle for analysis of

tritium, and two 40-ml glass bottles for analysis of the stable isotopes of hydrogen (H/D) and oxygen ($^{18}O/^{16}O$). The first two sample bottles for analysis of major cations and trace/minor inorganics and major anions and TDS were collected at all wells. The second two sample bottles for analysis of tritium and H/D and $^{18}O/^{16}O$ were collected only at selected wells. The samples that will be collected at each well are given in Table G-2.

The water sample collected for major cations and trace/minor inorganics analysis was filtered in the field prior to placement in the sample bottle in order to provide a sample for analysis of dissolved constituents only. This sample was filtered with a positive pressure filter. The filter pore size was 0.45 micrometers. Filters were changed and the filtration apparatus was cleaned before use at each well. The 500 ml sample bottle into which this sample was filtered contained concentrated nitric acid added to the bottle by the analytical laboratory supplying the bottles. Sufficient acid was added to the bottle to lower the pH of the water to less than 2, thereby preserving the sample. The bottle label was checked for accuracy and the bottle was placed in an ice chest containing ice in sealed (Ziploc type) plastic bags.

A second filtered sampled was collected for field determination of alkalinity. A Hach alkalinity test kit and a pH meter were used to make this measurement. The procedure is as follows:

1) Fill in header information on a titration form (Figure G-2).

2) Rinse the titration flask and volumetric flask with deionized water. Remove droplets of water by vigorous shaking.

3) Measure 100 ml of fresh, filtered sample in the volumetric flask and pour it into the titration flask with as little agitation as possible.

4) Rinse and pat dry the pH electrode and put it into the titration flask. Record the pH on the titration form.

5) Record the titrant lot number and normality on the titration form. Eject a few drops of titrant from the tip of the titrator and wipe the tip with a clean tissue. Reset the counter to 0000.

6) Titrate the solution with acid, gently stirring the solution to ensure mixing. When the pH=4.5, record the alkalinity value (in mg/l $CaCO_3$) on the titration form.

7) Rinse all glassware with distilled water.

8) Repeat the procedure.

9) Calculate the relative error between the two measurements as:

$$\frac{X1 - X2}{Xs} \times 100\%$$

where

X1 is the first alkalinity measurement at pH = 4.5
X2 is the second alkalinity measurement at pH = 4.5
Xs is the smaller of X1 and X2

10) If the relative error is greater than 10 percent, repeat the procedure until two consecutive measurements are within 10 percent relative error.

During cold weather the electronic pH meter was not functioning

properly. Under these circumstances it was necessary to obtain alkalinity measurements using indicator powder pillows provided in the alkalinity test kit. The procedure is as follows:

1) Fill in header information on titration form (Figure G-2).

2) Rinse the titration flask and volumetric flask with deionized water. Remove droplets by vigorous shaking.

3) Measure 100 ml of fresh, filtered sample in the volumetric flask with as little agitation as possible.

4) Add the contents of one phenophthalein indicator pillow and swirl to mix.

5) If the color turns pink, titrate with acid to a colorless end point and read and record the concentration of total alkalinity as mg/L $CaCO_3$. If a pink color does not develop, add the contents of one bromcresol green-methyl red indicator pillow to the same sample and swirl to mix.

6) Titrate with acid until a light pink color develops, then read and record the concentration of total alkalinity as mg/L $CaCO_3$.

7) Rinse all glassware and repeat the procedure.

8) Calculate the relative error between the two measurements as described previously.

9) If the relative error is greater than 10 percent, repeat the procedure until two consecutive measurements are within 10 percent relative error.

None of the other water samples were required to be field-filtered or preserved with acid. The sample for major anions and TDS was added directly to the 1000 ml plastic bottle and placed in the ice chest. The glass bottles used for holding the water samples collected for tritium and H/D and $^{18}O/^{16}O$ analyses were filled directly from the pump discharge line and then wrapped in bubblepack or other protective material to protect against breakage. The glass bottles did not need to be chilled with ice; however, they were stored in an ice chest or other sturdy container to prevent breakage.

4.0
SURFACE WATER SAMPLING

Selected water occurrences (primarily springs and seeps) were sampled and analyzed to provide background water quality data and aid in determining the source of the surface water. The surface water sites that were sampled are described in this section and the water sampling procedures are specified.

4.1 SURFACE WATER SAMPLING LOCATIONS

Samples of spring and seep water were collected at several locations in the vicinity of the proposed Thousand Springs power plant. Springs in the area were identified by accessing the BLM computer data base for the area, consulting topographic maps, and conducting a spring survey in the vicinity of the proposed facility. A preliminary list of springs and seeps that were sampled and their approximate locations are given in Table G-4. These springs and seeps were chosen for sampling because they may potentially be affected by the water production wells, they appear on topographic maps to be accessible by four-wheel drive vehicle, and they have a measured production of at least 0.5 gallons per minute. Secondary criteria used for choosing these locations include a distribution of sites between uplands and lowlands, a sampling of the hot springs, and samples from springs emanating from bedrock material and alluvium. The locations of the sampled springs and seeps are shown on Figure 5-1 of the Water Resources Evaluation.

4.2 SURFACE WATER SAMPLING

4.2.1 Preparations

Bottle types, preservatives, and special handling procedures are provided in Table G-3. These are identical to the methods used for water samples from the wells. The sample bottles were labeled with the spring identification, name of collector, date and time of collection, requested analyses, and any preservatives added to the water sample. Each suite of bottles were organized and labeled prior to commencing sampling. Each cooler in which sample bottles were stored was cleaned and dried prior to sampling.

On first arrival at a spring the date and time was noted on the surface water sampling form (Figure G-3). The physical condition of the water and surroundings was also noted on the form. This information included specifying whether the location is a spring or seep, the rock type from which the water is emanating, local topographic setting (gentle hill, steep cliff, creek bed, bottom land), type of vegetation, and use of the water by humans or animals (is the water piped to a tank or trough?). A photo was taken of the site. The discharge rate of the spring was measured using a calibrated container and chronometer. Where discharge from the spring was too great to measure with this method, an estimate was made of the discharge volume. All these observations and measurements were recorded on the surface water sampling form.

4.2.2 Spring Sampling Procedures

Water was collected from springs to make field measurements and provide samples for laboratory analyses. Where possible the water was collected directly in the container used to make the measurement or hold the sample. If the flow was not sufficient to allow for this, then the sample was collected first into a clean container that was rinsed with spring water and then transferred into the appropriate sample bottle.

The field measurement procedures and sample bottle protocols for the spring water samples are very similar to those for the groundwater samples. Temperature, pH, and specific conductance measurements were performed in the field immediately before and after sample collection as a check on the stability of these chemical parameters during sampling. The specific conductance and pH meters were calibrated prior to each day's work according to the manufacturer's specifications. A plastic container cleansed with nonphosphatic laboratory grade detergent and thoroughly rinsed first with deionized water and then with water collected from the spring was used to collect water for field measurement of temperature, pH, and specific conductance. When sampling of the spring was complete, the plastic container was rinsed thoroughly with water collected from the spring and a second set of temperature, pH, and specific conductance field measurements was performed. All of the results of the measurements were recorded on the surface water sampling form.

The order of filling the sample bottles is given in Table G-3. At most, four sample bottles were filled at each spring. In order of filling, these bottles are 500-ml plastic bottle for analysis for major cations and trace/minor inorganics, 1000-ml plastic bottle for analysis of major anions and total dissolved solids (TDS), 1000-ml glass bottle for analysis of tritium, and two 40-ml glass bottles for analysis of the stable isotopes of hydrogen (H/D) and oxygen ($^{18}O/^{16}O$). The first two sample bottles for analysis of major cations and trace/minor inorganics and major anions and TDS were collected at all springs. The second two sample bottles for analysis of tritium and H/D and $^{18}O/^{16}O$ were collected only at selected springs. The samples that were collected at each spring are given in Table G-4.

The water sample collected for major cations and trace/minor inorganics analysis was filtered in the field prior to placement in the sample bottle. This sample was filtered with a positive pressure filter. The filter pore size was 0.45 micrometers. Filters were changed and filtration

apparatus was cleaned prior to use at each spring. The 500 ml sample bottle into which this sample was filtered contained concentrated nitric acid added to the bottle by the analytical laboratory supplying the bottles. Sufficient acid was added to the bottle to lower the pH of the water to less than 2, thereby preserving the sample. The bottle label was checked for accuracy and the bottle was placed in an ice chest containing ice in sealed (Ziploc type) plastic bags.

A second filtered sampled was collected for field determination of alkalinity. A Hach alkalinity test kit and a pH meter were used to make this measurement. The procedure for measuring alkalinity is given above in Section 3.4.2.

None of the other water samples were required to be field filtered or preserved with acid. The sample for major anions and TDS was added directly to the 1000 ml plastic bottle and placed in the ice chest. Where possible, the glass bottles used for holding the water samples collected for tritium and H/D and $^{18}O/^{16}O$ analyses were filled directly from the point of discharge of the spring, otherwise the water was collected in a clean plastic container and transferred to the sample bottle. The bottles were then wrapped in bubble pack or other protective material to protect against breakage. The glass bottles did not need to be chilled with ice; however, they were stored in an ice chest or other sturdy container to prevent breakage.

5.0
SAMPLE HANDLING AND CHAIN-OF-CUSTODY PROCEDURES

5.1 SAMPLE HANDLING PROCEDURES

After sampling was completed at a well or spring, the bottle labels were checked for completeness and bottle caps tightened. Each glass bottle was rolled in bubblepack or other protective material. All bottles were placed upright in shipping containers. Padding was added used to ensure snugness of fit.

For shipment to the analyzing laboratory of samples that must be cooled, approximately ten pounds of ice was placed in each cooler. The ice was contained in sealed plastic bags so that free water was not allowed in the container. All shipping containers were sealed with strapping tape. The containers were kept in a secure location until shipment to the laboratories.

Samples were shipped before the most critical holding time of 7 days for total dissolved solids (TDS) analysis was exceeded. Sample distribution was as follows:

- Bottles for analysis of major cations and trace/minor inorganics (500-ml plastic bottle) and major anions and TDS (1000 ml plastic bottle) were sent to:

  California Analytical Laboratory
  2544 Industrial Blvd.
  West Sacramento, California 95691

(916) 372-1393

- Bottles for analysis of tritium (1000-ml glass bottle) were sent to:

  Dr. Gote Ostlund
  Rosenstiel School of Marine and Atmospheric Science
  Tritium Laboratory
  4600 Rickenbacker Causeway
  Miami, Florida 33149-1098
  (305) 361-4100

- Bottles for analysis of H/D and $^{18}O/^{16}O$ (2 x 40-ml glass) were sent to:

  Dr. Austin Long
  Laboratory of Isotope Geochemistry
  University of Arizona
  Tucson, Arizona 85721
  (602) 621-6014

The laboratory was contacted upon shipment of the samples and informed of the date and method of shipment, number of coolers, and any additional instructions.

5.2 CHAIN-OF-CUSTODY PROCEDURES

Samples were accompanied by a Chain-of-Custody Record (Figure G-4). When transferring the possession of samples, the individuals relinquishing and receiving signed and noted the date and time on the record. This record documents transfer of custody of samples from the sampler to the laboratory.

The Chain-of-Custody includes a Sample Analysis Request Section. This section identifies the parameters that are to be analyzed, the sample containers that were used for the respective analyses, and the preservation method used, if any.

One Chain-of-Custody Record was used per cooler. The original Record was sealed inside a plastic bag and placed inside the cooler. A copy was retained by the field sampler. Laboratory personnel were responsible for the care and custody of samples upon receipt.

6.0
LABORATORY PROCEDURES

6.1 SAMPLE BOTTLE PREPARATION

Sample bottles and coolers were supplied by the analyzing laboratories. Bottles were new or properly cleaned by the laboratory prior to shipment to the site. Preservatives were added by the laboratory as appropriate, and the bottles tightly capped to prevent leakage during shipment and storage prior to filling.

6.2 SAMPLE RECEPTION AND ANALYSIS

Upon arrival at the analytical laboratory, a sample custodian accepted custody of the shipped samples. The custodian inspected the sample containers for leakage, breakage, or other damage, and verified that the sample identification numbers on the bottle labels match those on the Chain-of-Custody Record. The record was signed and dated, and a copy returned with the report of analytical results.

The samples were given laboratory identification numbers and entered in the laboratory log book. All subsequent handling of the samples was noted in the log book. Samples that required storage at low temperature were refrigerated. Holding times and analytical methods are provided in Table G-5.

The sample custodian distributed the samples to the appropriate analysts. Laboratory personnel are responsible for the care and custody of samples from the time they were received until the sample was depleted, no longer suitable for analysis, or otherwise directed by the Project Manager.

7.0 QUALITY ASSURANCE/QUALITY CONTROL (QA/QC)

7.1 QA/QC PROCEDURES FOR FIELD WORK

All instruments, including water level sounders, pH meters, and specific conductance meters, were inspected for physical integrity and calibrated according to manufacturer's specifications prior to each days field activities. All instruments were cleaned with nonphosphatic laboratory grade detergent and rinsed with deionized water prior to use at each sampling location. All fragile instruments were stored in a padded protective plastic case during periods of nonuse and transport between sampling locations. Care was taken not to expose any temperature sensitive instruments to extreme heat or cold. All instruments were stored in a dry, room temperature environment during nights.

7.2 QA/QC SAMPLES

QA/QC samples were periodically prepared and submitted for analysis with the water samples. These samples consisted of sampling blanks and field duplicates. All QA/QC samples were given fictitious sample designations and handled and transported in the same manner as the groundwater and spring water samples. Both the correct and fictitious sample designations were recorded on the water sampling form. The QA/QC samples consisted of the following:

- Sampling blanks were used to assess potential contamination from the sampling method at the sampling site. One sampling blank was prepared in the field for every 10 field samples using

distilled/deionized water. The blanks were produced using the exact same procedures used for collecting the groundwater and spring water samples. Each sampling blank was analyzed for the complete set of parameters listed in Table G-1, except that only one tritium sampling blank was produced and analyzed because of the expense of the analysis.

- Field duplicates are water samples collected from the same well or spring at the same time. The analytical data from these samples are used to evaluate the precision of the sampling method. One duplicate sample was collected for every 10 samples and submitted for analysis. Each duplicate was analyzed for the complete set of parameters listed in Table G-1, except that only one tritium duplicate was produced and analyzed because of the expense of the analysis.

Laboratory QC documentation was obtained from the laboratory and reviewed for completeness. In addition the following QA checks were performed:

- Dates of sample analysis were compared with sample collection date to ensure that the samples were analyzed within the holding time specified in Table G-5.

- The respective sets of values from the duplicate samples were compared for agreement. Results from sampling blanks were reviewed.

- Charge balances were calculated by the laboratory using the major cations and anions. The balance should be less than 10 percent.

Discrepancies evident from the above QA/QC procedures were further investigated. Field notes and laboratory QA/QC documents were checked for accuracy.

Table G-1. SAMPLING PARAMETERS AND RATIONALE

Parameters	Rationale
Field Measurements	
Temperature	Indicator of thermal waters. Used in calculations of mineral equilibria.
pH	General water quality indicator. Master variable affecting speciation.
Specific Conductance	Field indicator of water quality. QA/QC.
Alkalinity	Measure of carbonate content of water. Necessary for ion speciation and mineral equilibria calculations.
Major Cations	
Calcium (Ca)	Major dissolved element. Necessary for calculations.
Magnesium (Mg)	Major dissolved element. Necessary for calculations.
Sodium (Na)	Major dissolved element. Necessary for calculations. Used for geothermometry.
Potassium (K)	Major dissolved element. Necessary for calculations. Used for geothermometry.
Silicon (Si)	Major dissolved element. Necessary for calculations. Indicator of geothermal activity.
Trace/Minor Inorganics	
Iron (Fe)	General indicator of water quality.
Manganese (Mn)	General indicator of water quality.
Copper (Cu)	General indicator of water quality.
Zinc (Zn)	General indicator of water quality.
Arsenic (As)	General indicator of water quality.
Barium (Ba)	General indicator of water quality.
Cadmium (Cd)	General indicator of water quality.
Chromium (Cr)	General indicator of water quality.
Selenium (Se)	General indicator of water quality.

Table G-1. SAMPLING PARAMETERS AND RATIONALE (concluded)

Parameters	Rationale
Antimony (Sb)	General indicator of water quality.
Lead (Pb)	General indicator of water quality.
Mercury (Hg)	General indicator of water quality.
Silver (Ag)	General indicator of water quality.
Lithium (Li)	Indicator of geothermal activity.
Boron (B)	Indicator of geothermal activity.
Major Anions	
Chloride (Cl)	Major dissolved element. Necessary for calculations.
Sulfate (SO_4)	Major dissolved element. Necessary for calculations.
Nitrate + Nitrite (NO_3 + NO_2)	Major dissolved element. Necessary for calculations.
Fluoride (F)	Major dissolved element. Necessary for calculations. Water quality indicator.
Others	
Total Dissolved Solids (TDS)	Indicator of usefulness of water to power plant. Can be used for QA/QC.
Tritium (^3H)	Age dating of water.
Hydrogen/Deuterium (H/D)	Used to classify origin of water.
$^{18}O/^{16}O$	Used to classify origin of water.

Table G-2. IDENTIFICATION OF WELLS TO BE SAMPLED AND SAMPLING PARAMETERS

Well Identification	Location	Parameters[a]
New Wells		
MW-1	42-65-35dd	F,1,2
MW-2	40-65-23cb	F,1,2
TW-3	39-66-5bc	F,1,2,3,4
MW-4	41-65-21bb	F,1,2
TW-12	41-66-31dc	F,1,2
TW-14	39-66-24ab	F,1,2
TW-15	39-66-9bc	F,1,2,3,4
Existing Wells		
Unnamed Well	40-65-10ca	F,1,2,3,4
Toano Well #1	40-65-24bd	F,1,2,3,4
Unnamed Well	41-64-25bb	3,4[b]
Unnamed Well	41-65-35ad	F,1,2,3,4
Fivemile Draw Well	41-66-33ac	F,1,2,3,4
Rocky Butte Well	41-67-22bc	F,1,2,3,4

[a] Sampling Parameters: F) field parameters: temperature, pH, specific conductance, alkalinity; 1) major cations (Ca, Mg, Na, K, Si) and trace/minor inorganics (Fe, Mn, Cu, Zn, As, Ba, Cd, Cr, Se, Sb, Pb, Hg, Li, B, Ag); 2) major anions (Cl, SO_4, NO_3+NO_2, F) and TDS; 3) tritium; 4) stable isotopes: H/D and $^{18}O/^{16}O$

[b] Sampled only for 3)tritium and 4)stable isotopes: H/D and $^{18}O/^{16}O$ because analytical results for trace/minor inorganics and major cations are available from a previous report by Guyton (1982).

Table G-3. SAMPLE BOTTLE ORDER OF FILLING, BOTTLE TYPE, PRESERVATIVES AND FILTRATION REQUIREMENTS FOR GROUNDWATER AND SURFACE WATER

Order of Filling	Parameters	Bottle Type	Volume	Preservation	Filtration
1	Major Cations, Trace/Minor Inorganics	Plastic	500 ml	HNO_3 to pH<2, Cool	0.45 micrometer pore size
2	Major Anions/TDS	Plastic	1000 ml	Cool	None
3	Tritium	Glass	1000 ml	None	None
4	H/D, $18_0/16_0$	Glass	40 ml (2)	None	None

Table G-4. IDENTIFICATION OF SPRINGS/SEEPS SAMPLED AND SAMPLING PARAMETERS

Spring Number	Location	Name	Sampling Parameter[a]
1	38-65-10ab	Pequop	F,1,2
2	39-64-14ab	Tripon Pass	F,1,2
3	40-64-21dc	Brush Creek	F,1,2
4	40-63-21ac	Ledge	F,1,2
5	40-63-18bb	Unnamed	F,1,2,3,4
6	40-65-6ac	Indian	F,1,2
7	41-64-25ac	Hot	F,1,2,3,4
8	41-64-26cd	Unnamed	F,1,2,3,4
9	42-65-6ca	Black Rock	F,1,2
10	44-69-30ac	Emigrant	F,1,2
11	42-69-8ac	Crittenden	F,1,2,3,4
12	40-69-8bc	Gamble	F,1,2,3,4
13	39-68-8bb	Near Montello Spring	F,1,2
14	39-67-10ac	North	F,1,2,3,4
15	39-67-15bb	Lewis	F,1,2

[a] Sampling Parameters: F) field parameters: temperature, pH, specific conductance, alkalinity; 1) major cations (Ca, Mg, Na, K, Si) and trace/minor inorganics (Fe, Mn, Cu, Zn, As, Ba, Cd, Cr, Se, Sb, Pb, Hg, Ag, Li, B); 2) major anions (Cl, SO_4, NO_3+NO_2, F) and TDS; 3) tritium; 4) stable isotopes: H/D and $^{18}O/^{16}O$

Table G-5. ANALYTICAL METHODS AND SAMPLE HOLDING TIMES

Parameters	Analytical Method(1)	Holding Time(2)
Field Measurements		
Temperature	EPA 170.1 (3)	(4)
pH	EPA 9040	(4)
Specific Conductance	EPA 9050	(4)
Alkalinity	EPA 310.1 (3)	(4)
Major Cations		
Ca	EPA 3005	6 months
Mg	EPA 3005	6 months
Na	EPA 3005	6 months
K	EPA 3005	6 months
Si	EPA 3005	6 months
Trace/Minor Inorganics		
Fe	EPA 3005	6 months
Mn	EPA 3005	6 months
Cu	EPA 3005	6 months
Zn	EPA 3005	6 months
As	EPA 3005	6 months
Ba	EPA 3005	6 months
Cd	EPA 3005	6 months
Cr	EPA 3005	6 months
Se	EPA 3005	6 months
Sb	EPA 3005	6 months
Pb	EPA 3005	6 months
Hg	EPA 245.2 (3)	28 days
Ag	EPA 3005	6 months
Li	EPA 3005	6 months
B	EPA 3005	6 months
Major Anions		
Cl	429 (5)	28 days
SO_4	429 (5)	28 days
NO_3+NO_2	429 (5)	28 days
F	413B (5)	28 days
Others		
TDS	160.1 (3)	7 days
Tritium	(6)	Not established
H/D	(7)	Not established
$18_0/16_0$	(7)	Not established

(1) All methods are taken from EPA Manual SW-846, Third Edition (1986) unless otherwise noted.
(2) Samples will be analyzed as soon as possible after collection. The times listed are the maximum that samples may be held before analysis and still be considered valid.
(3) Methods for Chemical Analysis of Water and Wastes, EPA-600/4-79-020 (1983)
(4) Analyze immediately.
(5) Standard Methods for the Examination of Water and Wastewater, 16th Edition, 1985.
(6) Low-level gas proportional counting.
(7) Mass Spectrometry

Ground-Water Sampling Form Sample Location ID: _____ Date: _____

Project Name: _____ Project Number: _____

Sampling Personnel: _____

Weather Conditions: _____

Observations/Comments: _____

Quality Assurance

Sampling Method:

Water Level Sounder Number: _____ Calibration Date: _____

pH Meter Number: _____ Calibration Date: _____

Specific Conductance Meter No.: _____ Calibration Date: _____

Organic Vapor Analyzer Serial No.: _____ Calibration Date: _____

Comments: _____

Well Bore Information

Time of Measurement: _____ OVA Reading: _____

Condition of Surface Casing: _____

Depth to Water (ft.): _____ Depth to Bottom of Well (DBW, ft.): _____

Original Well Depth (OWD, ft.): _____ Silt Height in Hole (OWD-DBW, ft.) _____

Height of Standing Water (h, ft.): _____ Vol. of Standing Water (gals.): _____

Reference Point Elevation: _____ Ground-water Elevation: _____

Sampling Measurements

Purging Method: _____

Time	Discharge (gallons)	pH	Sp. Conductance (umhos/cm)	Temp (C)	Comments

Total Discharge: _____ (gals) Casing Volumes Removed: _____

Comments: _____

Project No. 902708	Sierra Pacific Resources	GROUNDWATER SAMPLING FORM	Figure G-1
Woodward-Clyde Consultants			

ALKALINITY TITRATION FORM

SAMPLE LOCATION ID:

DATE/TIME:

PERSONNEL:

LOT NUMBER OF ACID:

NORMALITY OF ACID:

ERROR AT pH = 4.5:

$$\left| \frac{X1-X2}{Xs} \right| \times 100 = \quad \%$$

Xs = smaller of X1 and X2

1st = %

2nd = %

ALKALINITY

pH	(mg/l CaCO3)		
	1st	2nd	3rd
9.60			
9.30			
8.90			
8.60			
8.30			
8.05			
7.80			
7.50			
6.50			
5.70			
5.10			
4.80			
4.50			
4.25			
4.00			

ALKALINITY = mg/l CaCO3

Project No. 90270B	Sierra-Pacific Resources	ALKALINITY TITRATION FORM	Figure G-2
Woodward-Clyde Consultants			

Surface Water Sampling Form

Sample Location ID: _____ Date: _____

Project Name: _____ Project Number: _____

Sampling Personnel: _____

Weather Conditions: _____

Observations/Comments: _____

Quality Assurance

Sampling Method: _____

Specific Conductance Meter No.: _____ Calibration Date: _____

pH Meter No.: _____ Calibration Date: _____

Comments: _____

_____

Flow Rate Measurement

Method of Measurement: _____

_____

1. Time: _____ Measurement: _____ Comment: _____
2. Time: _____ Measurement: _____ Comment: _____
3. Time: _____ Measurement: _____ Comment: _____

Field Parameters

pH = _____ Temperature(C) = _____

Specific Conductance (micromhos/cm) = _____

Comments: _____

Project No. 90270B	Sierra Pacific Resources	SURFACE WATER SAMPLING FORM	Figure G-3
Woodward-Clyde Consultants			

Woodward-Clyde Consultants

500 12th Street, Suite 100, Oakland, CA 94607-4041
(415) 893-3600

Chain of Custody Record

PROJECT NO.

SAMPLERS: (Signature)

DATE	TIME	SAMPLE NUMBER	ANALYSES: General Mineral	Priority Pollutant Metals	EPA Method 624	EPA Method 625	EPA Method 608							Number of Containers	REMARKS (Sample preservation, handling procedures, etc.)

TOTAL NUMBER OF CONTAINERS

RELINQUISHED BY : (Signature)	DATE/TIME	RECEIVED BY : (Signature)	RELINQUISHED BY : (Signature)	DATE/TIME	RECEIVED BY : (Signature)

METHOD OF SHIPMENT :	SHIPPED BY : (Signature)	COURIER : (Signature)	RECEIVED FOR LAB BY : (Signature)	DATE/TIME

Figure G-4 CHAIN -OF-CUSTODY FORM

APPENDIX H
LABORATORY GEOCHEMICAL, WATER QUALITY, AND SOIL SAMPLING DATA REPORTS

Table 5-1 Sierra Pacific Spring and Well Water Analyses

	1	2	3	4	5	6	7	8	9	10
	Pequop Spring	Tripon Pass Spring	Brush Creek Spring	Ledge Spring	Unnamed Spring	Indian Spring	Hot Spring	Unnamed Spring	Black Rock Spring	Emigrant Spring
	38-65-10	39-64-14	40-64-21	40-63-21	40-63-18	40-65-6	41-64-25	41-64-26	42-65-6	44-69-30
Location Symbol on Figure 5-1	S1	S2	S3	S4	S5	S6	S7	S8	S9	S10
FIELD PARAMETERS										
pH	8.31	6.76	7.59	6.73	7.38	7.21	6.41	7.59	7.39	7.66
Temperature (degrees C)	14.5	9	18	16	14	13.1	60.9	9.3	11.9	15
Specific Conductance(umhos/cm)	390	1750	320	40	308	280	1650	340	430	290
Alkalinity as CaCO3(mg/L)	206	460	184	23.6	278(202)	130	431	213	240	135
MAJOR CATIONS (mg/L)										
Calcium	65	334	49	7.5	50	30	70	68	88(88)	41
Magnesium	13	241	20	0.8	20	16	16	18	23(24)	9.6
Sodium	26	33	7.2	1.9	6.9	23	104	20	5.3(5.3)	19
Potassium	6	<5.0	<5.0	<5.0	<5.0	<5.0	34	<5.0	<5.0(<5.0)	6
MAJOR ANIONS (mg/L)										
Chloride	20	120	7	4	6	24	21	13	10(10)	10
Sulfate	12	674	23	4	30	25	46	31	57(57)	35
Nitrite as N	<0.01	<0.01	<0.01	<0.1	<0.01	<0.01	<0.01	<0.01	<0.01(<0.01)	<0.01
Nitrate as N	0.7	<0.05	0.15	0.53	<0.05	0.36	<0.05	0.09	0.63(0.61)	<0.05
Fluoride	0.3	0.8	0.1	<0.1	0.4	0.4	1.8	0.2	0.2(0.2)	0.7
TRACE/MINOR INORGANICS (mg/L)										
Antimony	<0.05	<0.05	<0.05	<0.05	<0.05	<0.05	<0.05	<0.05	<0.05(<0.05)	<0.05
Arsenic	<0.1	<0.1	<0.1	<0.1	<0.1	<0.1	<0.1	<0.1	<0.1(<0.1)	<0.1
Barium	0.035	0.01	0.18	0.087	0.11	0.094	0.3	0.13	0.045(0.041)	0.092
Boron	0.07	0.1	0.03	<0.02	0.06	0.05	0.49	0.06	<0.02(<0.02)	0.05
Cadmium	<0.005	<0.005	<0.005	<0.005	<0.005	<0.005	<0.005	<0.005	<0.005(<0.005)	<0.005
Chromium	<0.01	<0.01	<0.01	<0.01	<0.01	<0.01	<0.01	<0.01	<0.01(<0.01)	<0.01
Copper	<0.006	<0.006	<0.006	<0.006	<0.006	<0.006	<0.006	<0.006	<0.006(<0.006)	<0.006
Iron	<0.05	4.7	<0.05	<0.05	0.45	<0.05	<0.05	<0.05	<0.05(<0.05)	<0.05
Lead	<0.05	<0.05	<0.05	<0.05	<0.05	<0.05	<0.05	<0.05	<0.05(<0.05)	<0.05
Lithium	<0.02	<0.02	<0.02	<0.02	<0.02	0.02	0.54	<0.02	<0.02(<0.02)	0.05
Manganese	<0.005	1	<0.005	<0.005	0.15	<0.005	0.079	<0.005	<0.005(<0.005)	<0.005
Mercury	<0.0002	<0.0002	<0.0002	<0.0002	<0.002	<0.0002	<0.0002	<0.0002	<0.0002(<0.0002)	<0.0002
Selenium	<0.2	<0.2	<0.2	<0.2	N.D.	<0.2	<0.2	<0.2	<0.2(<0.2)	<0.2
Silicon (Si)	14	8.6	6.3	4.4	5.7	8.6	31	12	5.2(5.2)	9
Silica (SiO2)	30	18	13	9.4	12	18	66	26	11	19
Silver	<0.005	<0.0057	<0.005	0.005	<0.005	<0.005	<0.0073	<0.005	<0.005(<0.005)	<0.005
Zinc	0.06	4.7	0.01	0.18	<0.01	<0.01	<0.01	<0.01	0.13(0.13)	<0.01
TOTAL DISSOLVED SOLIDS (mg/L)	344	2140	103	8	173	193	515	280	361(352)	1110
ION BALANCE (%)	5.6	18.1	2.6	21	2.1	0.64	0.5	3.6	2.7(2.7)	1.6
STABLE ISOTOPES										
Delta-D (0/00)	ND	ND	ND	ND	-129	ND	-137	-127	ND	ND
Delta O-18 (0/00)	ND	ND	ND	ND	-17.3(-17.4)LD	ND	-17.8	-16.9(-17.0)LD	ND	ND
TRITIUM (tritium units)	ND	ND	ND	ND	-0.03	ND	1.36	1.81	ND	ND

Table 5-1 Sierra Pacific Spring and Well Water Analyses

	11	12	13	14	15	16	17	18	19	20	21
	Crittenden Spring	Gamble Spring	Near Montello Spring	North Spring	Lewis Spring	MW-1	MW-2#	TW-3	MW-4	TW-12	TW-14
	42-69-8	40-69-8	39-68-8	39-67-10	39-67-15	42-65-35	40-65-23	39-66-5	41-65-21	41-66-31	39-66-24
Location Symbol on Figure 5-1	S11	S12	S13	S14	S15	MW-1	MW-2	TW-3	MW-4	TW-12	TW-14
FIELD PARAMETERS											
pH	7.84	7.87	7.69	7.5	7.52	8.77	ND	7.44	8.1	7.22	meter down
Temperature (degrees C)	16	21	9.7	10.5	11.8	21.5	ND	14.5	ND	17	22
Specific Conductance(umhos/cm)	330	365	350	350	580	390	ND	215	ND	235	240
Alkalinity as CaCO3(mg/L)	160	171	211	300	215	206	158	130	214	129	120
MAJOR CATIONS (mg/L)											
Calcium	50	49	65	70	78	25	42	34	34	30	30
Magnesium	15	19	21	18	36	8.5	10	5.7	16	11	9.7
Sodium	13	9.4	17	14	46	83	53	18	59	17	15
Potassium	<5.0	<5.0	<5.0	<5.0	< 5	7	<5.0	8	18	5	7
MAJOR ANIONS (mg/L)											
Chloride	16	12	19	20	20	8	64	3	17	7	12
Sulfate	28	32	40	19	34	36	65	17	46	17	19
Nitrite as N	<0.01	<0.01	<0.01	<0.01	<0.01	<0.01	<0.01	<0.01	<0.01	0.76	<0.01
Nitrate as N	0.64	0.21	0.41	0.88	0.43	<0.05	0.37	0.41	<0.05	<0.05	0.81
Fluoride	0.3	0.2	0.2	0.2	0.4	2.2	0.4	0.4	ND	0.4	0.4
TRACE/MINOR INORGANICS (mg/L)											
Antimony	<0.05	<0.05	<0.05	<0.05	<0.05	<0.05	<0.05	<0.05	ND	<0.05	<0.05
Arsenic	<0.1	<0.1	<0.1	<0.1	<0.1	<0.1	<0.1	<0.1	ND	<0.1	<0.1
Barium	0.089	0.11	0.075	0.11	0.045	0.027	0.049	0.039	ND	0.092	0.073
Boron	0.04	0.06	0.04	0.04	0.14	0.25	0.18	0.06	ND	0.07	0.06
Cadmium	<0.005	<0.005	<0.005	<0.005	<0.005	<0.005	<0.005	<0.005	ND	<0.005	<0.005
Chromium	<0.01	<0.01	<0.01	<0.01	<0.01	<0.01	<0.01	<0.01	ND	<0.01	<0.01
Copper	<0.006	<0.006	<0.006	<0.006	<0.006	<0.006	<0.006	<0.006	ND	<0.006	<0.006
Iron	<0.05	<0.05	<0.05	<0.05	<0.05	<0.05	<0.05	0.1	0.12	<0.05	0.08
Lead	<0.05	<0.05	<0.05	<0.05	<0.05	<0.05	<0.05	<0.05	ND	<0.05	<0.05
Lithium	<0.02	<0.02	<0.02	<0.02	0.03	0.03	0.03	<0.02	ND	<0.02	<0.02
Manganese	<0.005	<0.005	<0.005	<0.005	<0.005	<0.005	0.014	0.01	0.01	0.016	0.01
Mercury	<0.0002	<0.0002	<0.0002	<0.0002	<0.0002	<0.0002	<0.0002	<0.0002	ND	<0.0002	<0.0002
Selenium	<0.2	<0.2	<0.2	<0.2	<0.2	<0.002	0.004	<0.2	ND	<0.2	<0.2
Silicon (Si)	11	7.1	6.2	6.6	9.7	30	18	38	35.5	28	35
Silica (SiO2)	24	15	13	14	21	64	39	81	76	56	75
Silver	<0.005	<0.005	<0.005	<0.005	<0.005	<0.005	<0.005	<0.005	ND	<0.005	<0.005
Zinc	<0.01	<0.01	0.01	0.08	0.13	<0.01	<0.01	<0.01	ND	0.09	0.11
TOTAL DISSOLVED SOLIDS (mg/L)	228	224	304	285	327	376	421	240	ND	187	229
ION BALANCE (%)	0.6	1.8	0.87	12	3.8			1.3	ND		
STABLE ISOTOPES											
Delta-D (0/00)	-128.0(-129.5)LD	-130.5	ND	-127(-125)FD	ND	ND	ND	-138.0	ND	ND	ND
Delta O-18 (0/00)	-17.6	-17.5	ND	-16.7(-16.9)FD	ND	ND	ND	-18.4	ND	ND	ND
TRITIUM (tritium units)	0.10	-0.01	ND	12.6(18.6)FD	ND	ND	ND	0.06	ND	ND	ND

Table 5-1 Sierra Pacific Spring and Well Water Analyses

	22	23	24	25	26.0	27	28
	TW-15	Toano Well #1	Unnamed Well	Rocky Butte Well	Unnamed Well	Fivemile Draw Well	Unnamed Well 28
	39-66-9	40-65-24	40-65-10	41-67-22	41-64-25	41-66-33	41-65-35
Location Symbol on Figure 5-1	TW-15	24bd	10ca	22bc	25bb	33ac	35ad
FIELD PARAMETERS							
pH	7.7	7.5	8.55	8.25	ND	7.54	ND
Temperature (degrees C)	N.D	10	16.5	20.5	ND	12.5	ND
Specific Conductance(umhos/cm)	N.D.	280	330	320	ND	880	ND
Alkalinity as CaCO3(mg/L)	124	108	165	121	ND	227	132.0
MAJOR CATIONS (mg/L)							
Calcium	32	51	34	35	ND	128	44
Magnesium	10	8.8	6.7	7	ND	61	6.5
Sodium	15	22	54	25	ND	53	33
Potassium	6	5	9	13	ND	13	10
MAJOR ANIONS (mg/L)							
Chloride	7	24	9	12	ND	21	11
Sulfate	21	47	50	29	ND	344	44
Nitrite as N	<0.01	<0.01	<0.01	<0.01	ND	<0.01	<0.01
Nitrate as N	1.1	1.6	0.43	1.5	ND	3.4	0.52
Fluoride	0.3	0.3	0.6	0.4	ND	0.5	0.4
TRACE/MINOR INORGANICS (mg/L)							
Antimony	<0.05	<0.05	<0.05	<0.05	ND	<0.05	<0.05
Arsenic	<0.1	<0.1	<0.1	<0.1	ND	<0.1	<0.1
Barium	0.12	0.061	0.055	0.071	ND	0.04	0.079
Boron	0.06	0.06	0.12	0.1	ND	0.14	0.10
Cadmium	<0.005	<0.005	<0.005	<0.005	ND	<0.005	<0.005
Chromium	<0.01	<0.01	<0.01	<0.01	ND	<0.01	<0.01
Copper	<0.006	<0.006	<0.007	<0.006	ND	<0.007	<0.006
Iron	<0.05	<0.05	0.13	<0.05	ND	<0.05	<0.05
Lead	<0.05	<0.05	<0.05	<0.05	ND	<0.05	<0.05
Lithium	<0.02	<0.02	0.04	0.02	ND	0.11	0.03
Manganese	<0.005	<0.005	0.009	0.005	ND	<0.005	<0.005
Mercury	<0.0002	<0.0002	<0.0002	<0.0002	ND	<0.0002	<0.0002
Selenium	<0.2	<0.2	<0.2	<0.2	ND	<0.2	<0.2
Silicon (Si)	28	27	38	33	ND	30	39
Silica (SiO2)	60	58	81	71	ND	64	83
Silver	<0.005	<0.005	<0.005	<0.005	ND	<0.005	<0.005
Zinc	0.12	<0.01	0.01	0.21	ND	0.11	<0.01
TOTAL DISSOLVED SOLIDS (mg/L)	203	310	330	260	ND	920	330
ION BALANCE (%)		4.2	2.4	4.7	-	6.1	-
STABLE ISOTOPES						6.1	
Delta-D (0/00)	-136.0	-132.0	-137.0	-128.0	-133.0	-122.0	-137.0
Delta O-18 (0/00)	-18.6	-17.2	-17.9	-16.3 (-16.4 LD)	-17.7	-15.7	-18.0
TRITIUM (tritium units)	0.15	0.60	-0.08	0.00	0.00	1.25	-0.07
	FD=Field Duplicate, LD=Lab Duplicate						
	( ) Values in parantheses are field or lab duplicate analyses						
	#Sample not chilled or preserved, holding times exceeded for TDS						
	ND=No Data						

PETROGRAPHIC STUDY

FOR

WOODWARD-CLYDE CONSULTANTS

The analyses, opinions or interpretations contained in this report are based upon observations and material supplied by the client for whose exclusive and confidential use this report has been made. The interpretations or opinions expressed represent the best judgement of Core Laboratories. Core Laboratories assumes no responsibility and makes no warranty or representations, express or implied, as to the productivity, proper operations, or profitableness however of any oil, gas, coal or other mineral, property, well or sand in connection with which such report is used or relied upon for any reason whatsoever.

Western Atlas International
(A Litton Dresser Company)

CORE LABORATORIES

February 7, 1989

Mr. Kelly Teague
Woodward-Clyde Consultants
Oakland City Center
500 12th Street, Suite 100
Oakland, CA 94607-4014

Subject: Petrographic Study (X-ray Diffraction and Thin Section Petrography Analyses)
File: 189015

Dear Mr. Teague:

This report presents the final results of a Petrographic Study performed on five (5) unconsolidated samples . The Petrographic Study includes analyses by X-ray Diffraction (XRD) and Thin Section Petrography of Samples No.23 (208-218 feet), No.26 (238-248 feet), No.29 (268-278 feet), No.32 (298-308 feet), and No.35 (328-338 feet).

It has been a pleasure performing this study for Woodward-Clyde Consultants. Should you have any questions about these analyses, or if we can be of further assistance, please do not hesitate to contact us.

Sincerely,

CORE LABORATORIES
Reservoir Geology Group

Debra J. Malek
Petrologist

Susan P. Grier
Supervisor

1300 East Rochelle Boulevard Irving, Texas 75062-3963 P.O. Box 152053, Irving, Texas 75015-2053, (214) 541-2673, (800) 248-CORE

PROJECT REVIEW

Debra J. Malek
Petrologist

Malcolm S. Jones
X-ray Petrologist

Mark A. Smesny
Thin Section Preparation

Federica M. Ballentine
Reviewer

TABLE OF CONTENTS

SUMMARY 1

ANALYTICAL PROCEDURES 2

REFERENCES 3

TABLE 1: THIN SECTION ANALYSES: GENERAL DESCRIPTIONS

TABLE 2: X-RAY DIFFRACTION ANALYSES: BULK AND CLAY

THIN SECTION PHOTOMICROGRAPHS AND DESCRIPTION

PLATE 1 - SAMPLE NO.23 DEPTH (208-218 FEET)
PLATE 2 - SAMPLE NO.26 DEPTH (238-248 FEET)
PLATE 3 - SAMPLE NO.29 DEPTH (268-278 FEET)
PLATE 4 - SAMPLE NO.32 DEPTH (298-308 FEET)
PLATE 5 - SAMPLE NO.35 DEPTH (328-338 FEET)

SUMMARY

The Reservoir Geology Group of Core Laboratories in Irving, Texas, received five (5) unconsolidated sediment samples on January 13, 1989, from Woodward-Clyde Consultants. The designated sample numbers are the following: No.23 (208-218 feet depth), No.26 (238-248 feet depth), No.29 (268-278 feet depth), No.32 (298-308 feet depth), and No.35 (328-338 feet depth). The purpose of this report is to supply petrologic data about the samples to Sierra Pacific Resources, a client of Woodward-Clyde Consultants. X-ray Diffraction analyses of the bulk and clay fractions and Thin Section Petrography analyses were performed on each of the five samples. The objectives of this study were to characterize the lithology and textures of the samples, with particular attention to the abundance and distribution of carbonate minerals, pyrite, and porosity.

Analyses reveal that the samples are poorly consolidated tuffs of volcanic origin. Primary constituents of rock fragments, crystals, and glass shards, are set in a groundmass of clay and devitrified glass. A general description of each sample is provided in Table 1. Rock fragments in these samples are mostly volcanics, chert, sandstone, and argillite, with lesser amounts of micrite clasts and undifferentiated rock fragments. Crystals include plagioclase, quartz, muscovite, hornblende, and pyroxene. The average size of these constituents is less than 2 millimeters (ash-size), although fragments up to 8.58 millimeters long (lapilli-size) were measured. The constituents are randomly oriented within the groundmass of the sample.

Trace abundances of calcite cement (Sample No.26) and pyrite (Samples No. 26, 29, 32, and 35) were observed in the thin section. Most of the pyrite in these samples has been replaced by iron-oxides. Iron-oxide minerals observed in these samples are limonite, goethite, and magnetite.

X-ray Diffraction analyses reveal that variable amounts of calcite (3.4 to 10.9 weight percent) and pyrite (0.4 to 1.7 percent), as well as heulandite (0.4 to 2.2 percent) are present (Table 2). Thin section analyses suggest that most of the calcite detected by XRD analyses is in the form of micrite. The range of weight percentages of the minerals reported by XRD is interpreted to be due in part to sample heterogeneity.

Porosity observed in these samples is mostly comprised of microporosity and porosity within the groundmass. Porosity appears to have been enhanced by disaggregation of the poorly consolidated samples. Minor to trace amounts of intragranular porosity is present, mostly in the form of isolated moldic pores within rock fragments, and less commonly as fractures through grains.

ANALYTICAL PROCEDURES

A Petrographic Study allows for characterization of reservoir rock texture, mineralogy, and porosity. Information about the relationships among rock textures, detrital grains, cement and matrix composition, and porosity characteristics are determined from thin section analyses. XRD analysis provides mineral compositions and abundances.

The sample fraction selected for XRD analysis is first cleaned of hydrocarbon residue, weighed, and disaggregated using standard techniques. The sample is then centrifugally size-fractionated (in water) into a clay-size fraction (less than 4 microns) and a sand/silt-size fraction. The clay fraction is suspended in water and deposited on a porous silver substrate. Each clay fraction is analyzed dry (RH=50%) and then after treatment with ethylene glycol. The sand/silt-size fraction is made into a pellet using standard powder techniques. The prepared samples are run on a Philips APD3600 X-ray diffractometer at a slow rate (1 degree/minute) with kv = 1, ma = 35, scintillator kv = 0.8, and a time constant of 1.

Compositions and species of the clay minerals are determined according to procedures outlined by Weaver (1956), Jonas and Brown (1959), Reynolds (1980), and Srodon (1980, 1984). The weight percents of the rock-forming minerals in both size fractions and the relative abundances of the clay minerals are determined by a standardless, peak-area-ratio model. The detectability limit is 1-2 weight percent.

The sample fractions are prepared for Thin Section Analysis by first impregnating the sample with epoxy to augment sample cohesion and to prevent loss of material during grinding. A blue dye is added to the epoxy to highlight the pore spaces. Each sample is mounted on a frosted glass slide and then cut and ground in water to an approximate thickness of 30 microns. Samples containing known water-soluble phases are prepared using odorless kerosene. Prepared thin sections are subsequently stained for calcite (Alizarin Red-S stain), iron-bearing carbonates (potassium ferricyanide stain), and potassium feldspar (sodium cobaltinitrate stain) as necessary. The thin sections are analyzed using standard petrographic techniques. The terminology in this report is that of Folk (1980) and Best (1982).

REFERENCES

Best, M.G., 1982, Igneous and Metamorphic Petrology: W.H. Freeman and Company, San Fransico, CA, p. 69-95.

Folk, R.L., 1980, Petrology of Sedimentary Rocks: Hemphill Publishing Company, Austin, Texas, p. 184.

Goddard, E.N., P.D. Trask, R.K. DeFord, O.N. Rove, J.T. Singewald, and R.M. Overbeck, 1980, Rock Color Chart: Geological Society of America, Boulder, Colorado.

Jenkins. R., Y. Hahm, and S. Pearlman, 1979, The APD3600, a new dimension in qualitative and quantitative x-ray powder diffractometry: Norelco Reporter 26.

Jonas, E.C. and T.E. Brown, 1959, Analysis of interlayer mixtures of three clay mineral types by X-ray diffraction: Journal of Sedimentary Petrology, Volume 20, p. 77-86.

Reynolds, R.C. Jr., 1980, Interstratified clay minerals, in G.W. Brindley and G. Brown, eds., Crystal structures of clay minerals and their X-ray identification: Mineral Society of London, p. 249-303.

Schreiner, W.N. and R. Jenkins, 1983, Profile fitting for quantitative analysis in x-ray powder diffraction: Advances in X-Ray Analysis 26p.

Srodon, J., 1980, Precise identification of illite/smectite interstratifications by X-ray powder diffraction: Clay and Clay Minerals, Volume 28, p. 401-411.

Srodon, J., 1984, X-ray powder diffraction identification of illitic materials: Clays and Clay Minerals, Volume 32, p. 337-349.

Weaver, C.E., 1956, The distribution of mixed-layer clays in sedimentary rocks: American Mineralogist, Volume 41, p. 202-221.

Woodward-Clyde Consultants
Unconsolidated sediment samples

TABLE 1
THIN SECTION ANALYSES: GENERAL DESCRIPTION

FILE: 189015

Sample Number:	23	26	29
Sample Depth (Feet):	208-218	238-248	268-278
Rock Type	Volcaniclastic	Volcaniclastic	Volcaniclastic
Rock Name	Lithic lapilli tuff	Lapilli ash tuff	Lapilli ash tuff
Primary Constituents: (In order of estimated abundance)	Rock fragments (chert, argillite, sandstone, volcanic, undifferentiated), plagioclase, quartz, glass shards, pyroxene, potassium feldspar	Rock fragments (volcanics, chert, sandstone, argillite, undifferentiated, micrite), plagioclase, quartz, glass shards, muscovite, hornblende	Rock fragments (volcanics, chert, sandstone, argillite, undifferentiated, micrite), glass shards, plagioclase, quartz, pyroxene, hornblende
Alteration Minerals: (In order of estimated abundance)	Undifferentiated clay, iron-oxides, devitrified glass	Undifferentiated clay, devitrified glass, iron-oxides, pyrite	Undifferentiated clay, devitrified glass, iron-oxides, cristobalite, pyrite
Grain Size			
Minimum:	-----	0.02mm (ash)	0.02mm (ash)
Maximum:	-----	3.80mm (lapilli)	8.58mm (lapilli)
Average:	8.0-11.0mm (lapilli)	0.55mm (ash)	0.71mm (ash)
Orientation:	Random orientation of grains in matrix	Random orientation of grains in matrix	Random orientation of grains in matrix
Cement/Matrix:	Undifferentiated clay, devitrified glass	Undifferentiated clay, devitrified glass	Undifferentiated clay, devitrified glass
Texture:	Hypocrystalline	Hypocrystalline	Hypocrystalline
Porosity Types:	Fractures, moldic pores, microporosity in groundmass	Microporosity and porosity in groundmass, fractures (caused by sample disaggregation)	Microporosity and porosity in groundmass, trace of intragranular pores
Comments:	Most of this thin section consists of rock fragments; pyrite has been altered to iron-oxides	Trace of pyrite (most is altered to iron-oxides); minor detrital clasts of silty micrite are present	Minor silty micrite clasts; trace of pyrite

Woodward-Clyde Consultants

TABLE 1

FILE: 189015

Unconsolidated sediment samples

THIN SECTION ANALYSES: GENERAL DESCRIPTION

Sample Number:	32	35
Sample Depth (Feet):	298-308	328-338
Rock Type	Volcaniclastic	Volcaniclastic
Rock Name	Lapilli ash tuff	Lapilli ash tuff
Primary Constituents: (In order of estimated abundance)	Rock fragments (volcanics, chert, micrite, sandstone, argillite, undifferentiated), glass shards, plagioclase, quartz, pyroxene, hornblende	Rock fragments (volcanics, chert, argillite, sandstone, undifferentiated), glass shards, plagioclase, quartz, pyroxene
Alteration Minerals: (In order of estimated abundance)	Devitrified glass, undifferentiated clay, iron-oxides, cristobalite, pyrite	Undifferentiated clay, devitrified glass, iron-oxides, minor crystalline carbonate cement; trace of pyrite
Grain Size		
Minimum:	0.03mm (ash)	0.05mm (ash)
Maximum:	2.03mm (lapilli)	2.96mm (lapilli)
Average:	0.29mm (ash)	0.40mm (ash)
Orientation:	Random orientation of grains in matrix	Random orientation of grains in matrix
Cement/Matrix:	Undifferentiated clay, devitrified glass	Undifferentiated clay, devitrified glass
Texture:	Hypocrystalline	Hypocrystalline
Porosity Types:	Microporosity and porosity in groundmass	Localized microporosity in groundmass, trace of intragranular microporosity
Comments:	Amygdaloidal volcanic rock fragments; silicified biopackstones; minor silty micrite clasts; trace of pyrite	Fractures and most pores in matrix appear to be caused by sample disaggregation; minor silty micrite clasts

Table 2

QUANTITATIVE X-RAY DIFFRACTION ANALYSES

Depth (Feet)	208-18	238-48	268-78	298-308	328-338
CALCULATED WHOLE-ROCK COMPOSITION					
QUARTZ	62.5	53.4	44.9	47.4	63.2
PLAGIOCLASE	18.6	22.3	21.2	27.0	17.9
ALKALI FELDSPAR	0.0	0.0	1.7	0.0	0.0
CALCITE	3.4	10.9	8.2	4.6	4.1
HEULANDITE	1.8	2.2	1.4	3.5	4.3
PYRITE	0.5	0.5	1.7	0.7	0.4
CLAY MINERALS	13.2	10.6	20.9	16.9	10.2
	100.0	100.0	100.0	100.0	100.0
RELATIVE CLAY ABUNDANCE (Normalized to 100)					
ILLITE	58.0	43.6	44.1	55.1	66.8
SMECTITE	42.0	56.4	55.9	44.9	33.2
	100.0	100.0	100.0	100.0	100.0

THIN SECTION PHOTOMICROGRAPHS

The scale of the photomicrographs in each plate is a function of the magnification:

31X: Horizontal width of the photomicrograph (127mm) represents 4.097mm.

125X: Horizontal width of the photomicrograph (127mm) represents 1.016mm.

SAMPLE NO. 23

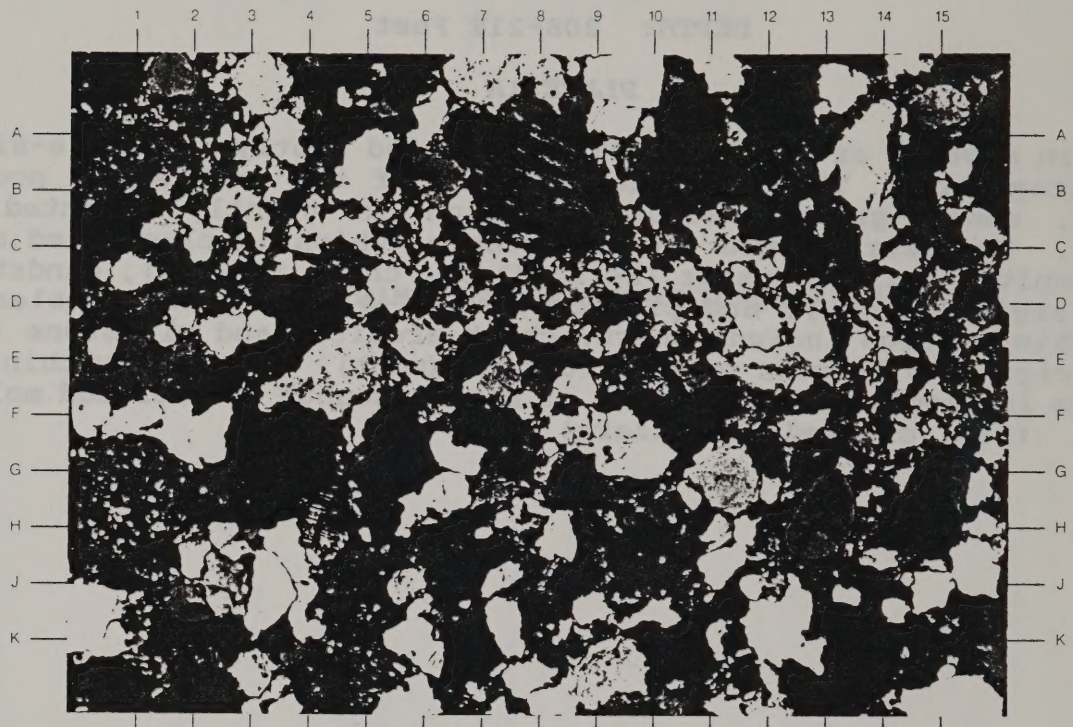
DEPTH: 208-218 Feet

PLATE 1A

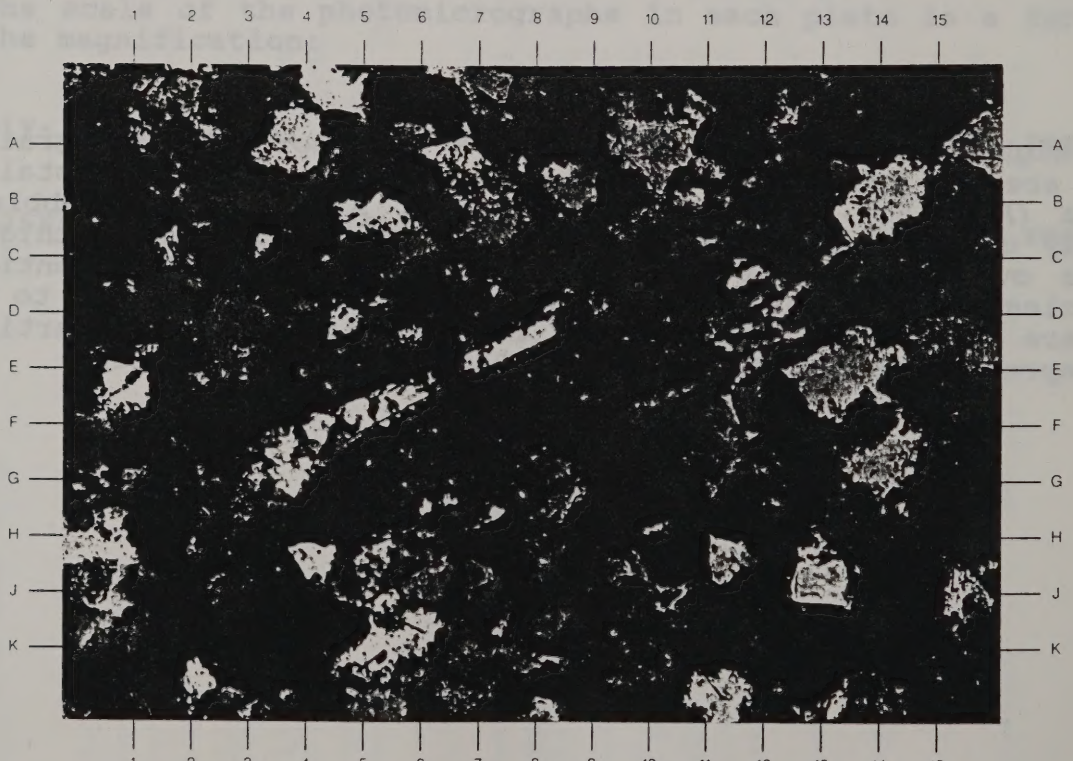
The thin section of Sample No.23 is composed mostly of pebble-sized rock fragments. This view depicts one of the pebbles, a poorly sorted, medium-grained sandstone which is tightly cemented by quartz. Framework grains in this pebble, which is classified as a litharenite, include quartz (E4.5, J3.5), chert (H-J6.5), sandstone (G1), argillite (H9), and plagioclase (H4-4.5). Other pebbles in this thin section include chert, chert arenite, and claystone (may have originally been an igneous rock fragment). Porosity within the pebbles in Sample No.23 consists of minor amounts of isolated moldic pores. (31X, crossed polarizers)

PLATE 1B

This highly magnified view depicts a well-sorted, fine-grained, chert arenite pebble. Framework grains are mostly monocrystalline quartz (A10, E13.5) and chert (H14, D1, A7.5). This pebble is tightly cemented by abundant chert (K7, G5 to E10) and authigenic quartz overgrowths (A9-9.5). Several elongate undifferentiated particles, such as the one in the center of this view (F3-J5 to C11-D13) are present in this pebble. These undifferentiated particles may represent fossil fragments. (125X, crossed polarizers)


1 2 3 4 5 6 7 8 9 10 11 12 13 14 15
A B C D E F G H J K

A


1 2 3 4 5 6 7 8 9 10 11 12 13 14 15
A B C D E F G H J K

B

SAMPLE NO. 26

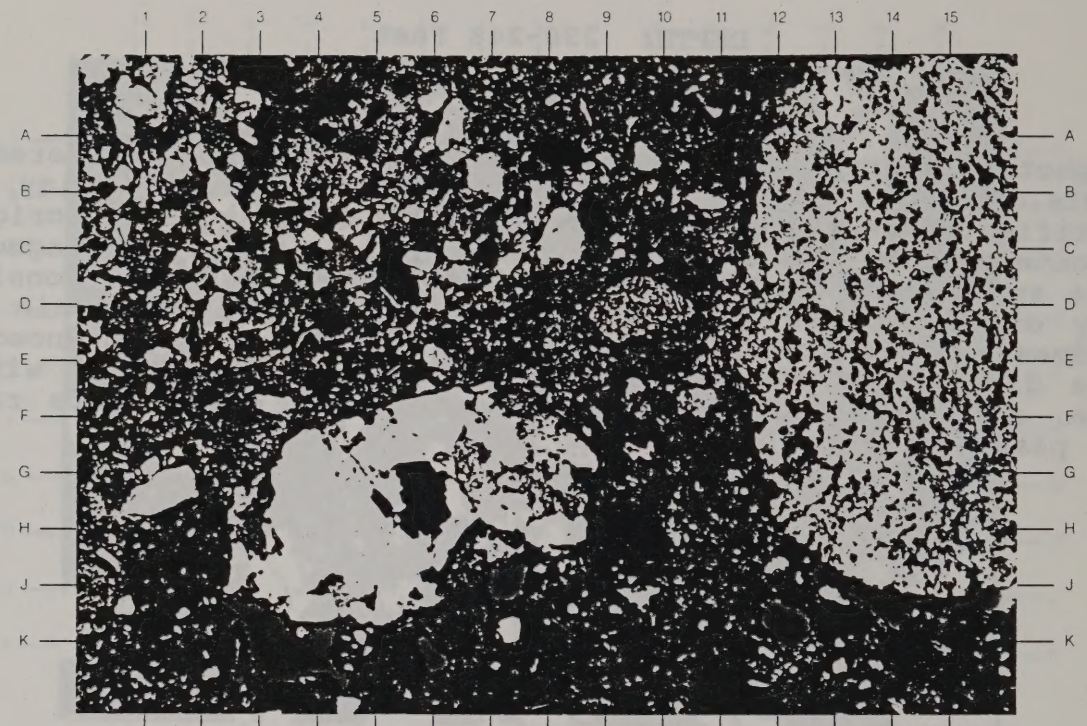
DEPTH: 238-248 Feet

PLATE 2A

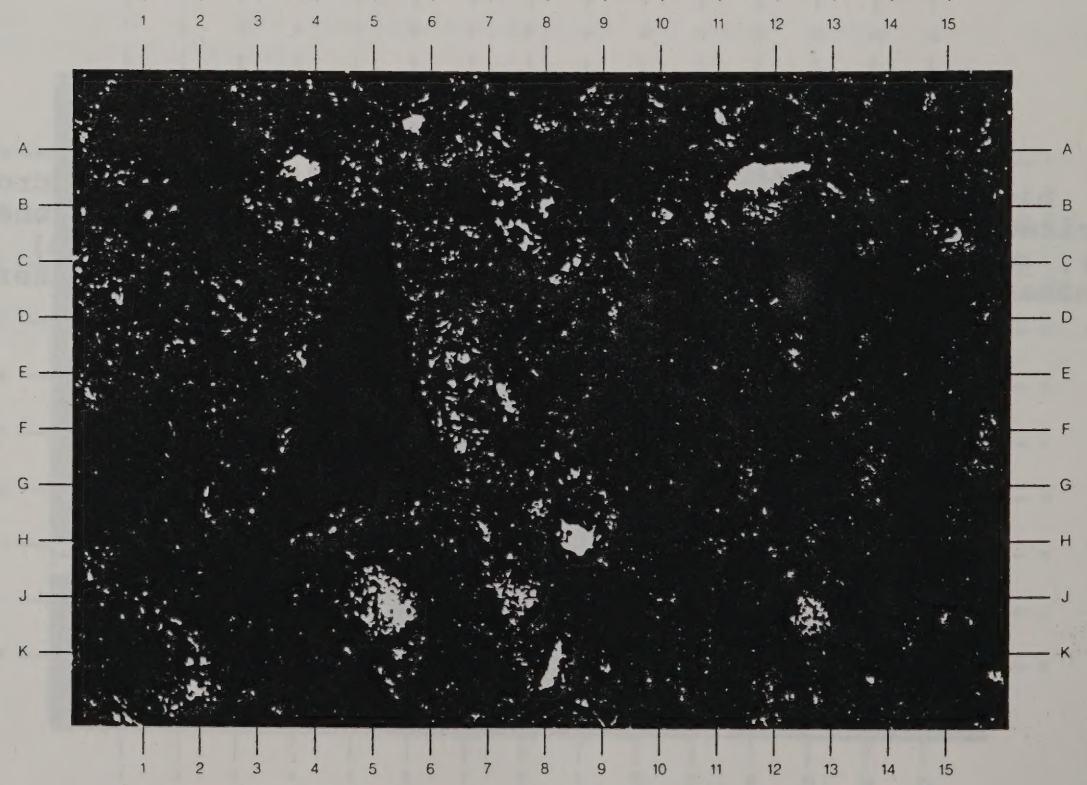
This photomicrograph illustrates three rock fragments (centered at B3, D14, and H5) in a groundmass of undifferentiated clay and devitrified glass. The rock fragment at B3 is of volcanic origin, and contains crystals in a glassy groundmass. The rock fragments at D14 and H5 are sandstones. Porosity in Sample No.26 consists mostly of micropores (H0-0.5) and pores (K3.5, K12) within the groundmass. Porosity in the groundmass may have been enhanced by sample disaggregation during sample handling. Fractures within grains, although interpreted to be natural in origin, are rare. (31X, plane-polarized light)

Plate 2B

This high magnification photomicrograph taken under crossed polarized light highlights glass shards (C-G5, C-D7), pyroxene (E-F6.5), monocrystalline quartz (A-B3.5-4), and chert (B7.5) in a groundmass of undifferentiated clay. (125X, crossed polarizers)


1 2 3 4 5 6 7 8 9 10 11 12 13 14 15
A B C D E F G H J K

A


1 2 3 4 5 6 7 8 9 10 11 12 13 14 15
A B C D E F G H J K

B

SAMPLE NO. 29

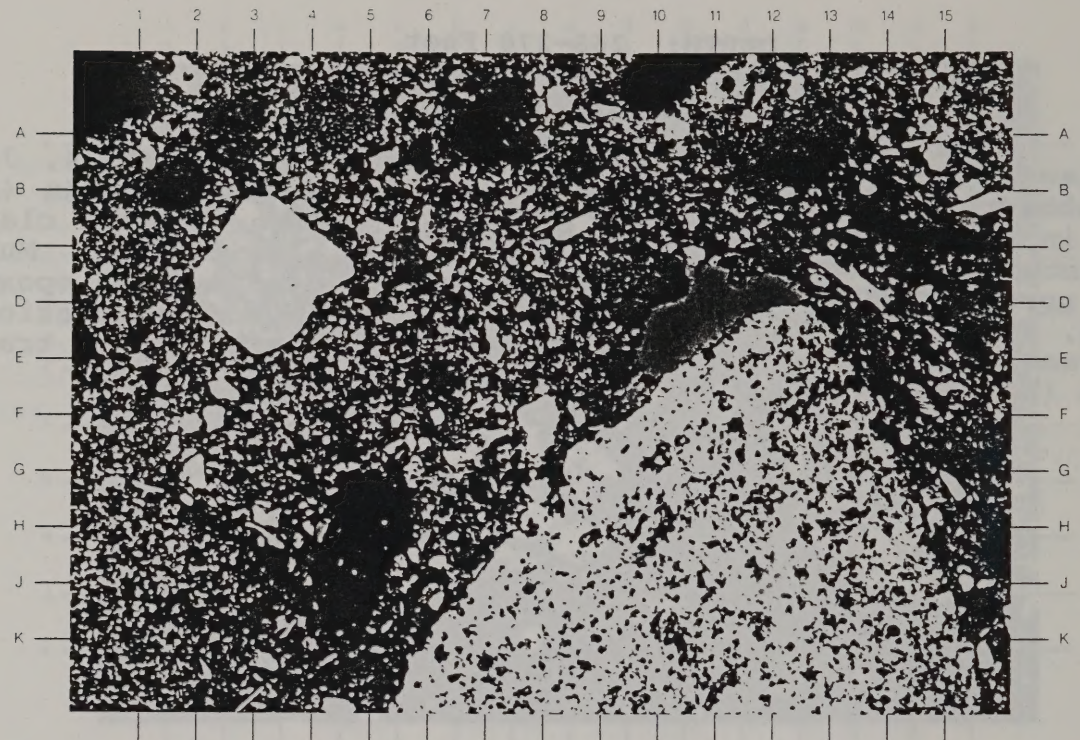
DEPTH: 268-278 Feet

PLATE 3A

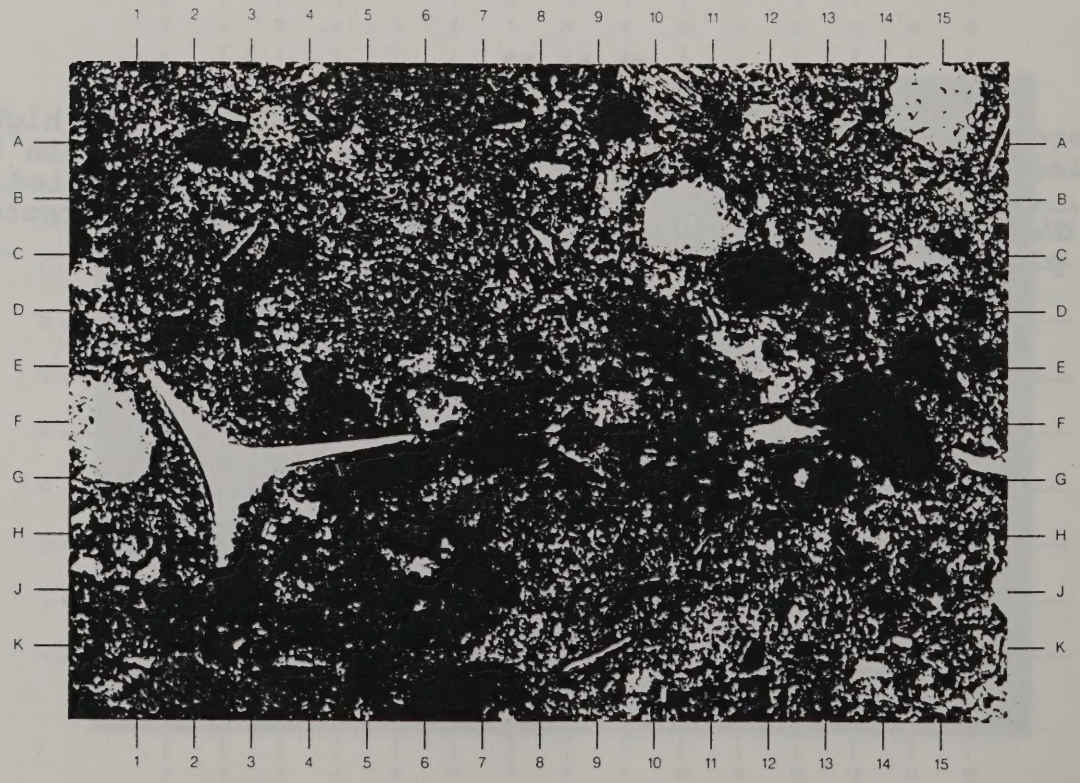
This view of a lapilli ash tuff shows rock fragments (H8-14, J1, A7), subhedral crystals (plagioclase; C3), and glass shards (C-D13.5) in a groundmass comprised mostly of undifferentiated clay. Minor amounts of micrite clasts (A3, A4.5) are also present. Much of the porosity within the groundmass of this sample (blue epoxy; F-G15.5, D11) may be an artifact of sample disaggregation. Intragranular pores within rock fragments are present in trace amounts (H13.5). (31X, plane-polarized light)

Plate 3B

Microporosity within a clay-rich matrix is depicted by this highly magnified view of the sample (D4.5, J-K4-6). Glass shards in the sample, such as the one located at G3, are easily identified by their distinctive shape and their isometric optical character. (125X, plane-polarized light)


1 2 3 4 5 6 7 8 9 10 11 12 13 14 15
A B C D E F G H J K

A


1 2 3 4 5 6 7 8 9 10 11 12 13 14 15
A B C D E F G H J K

B

SAMPLE NO. 32

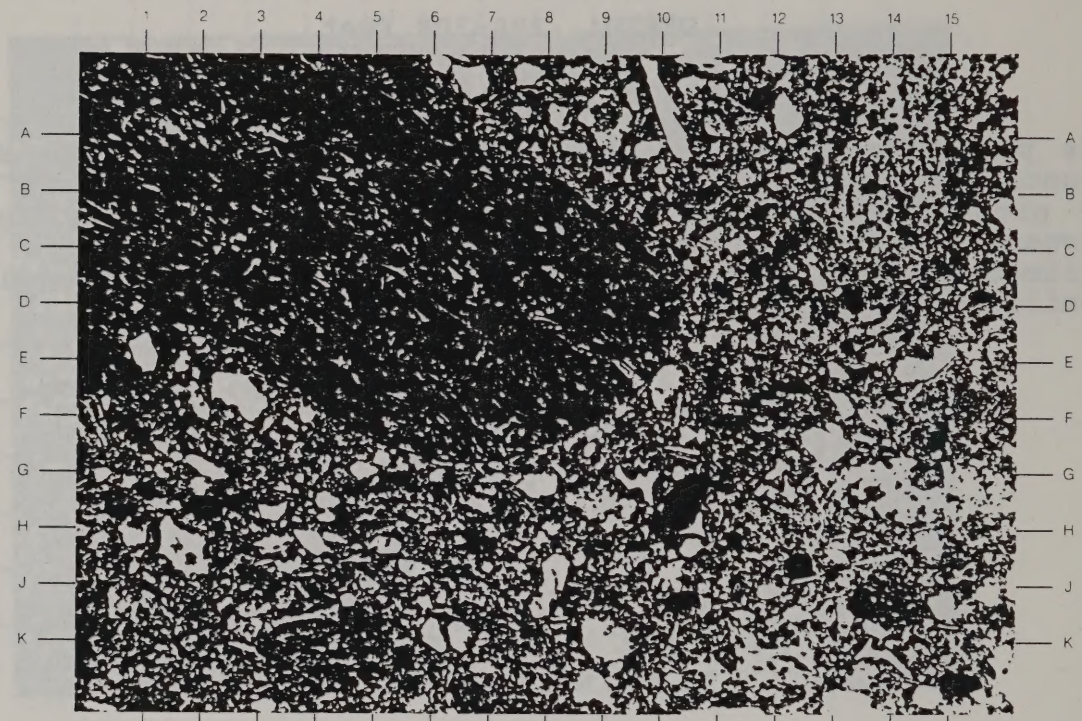
DEPTH: 298-308 Feet

PLATE 4A

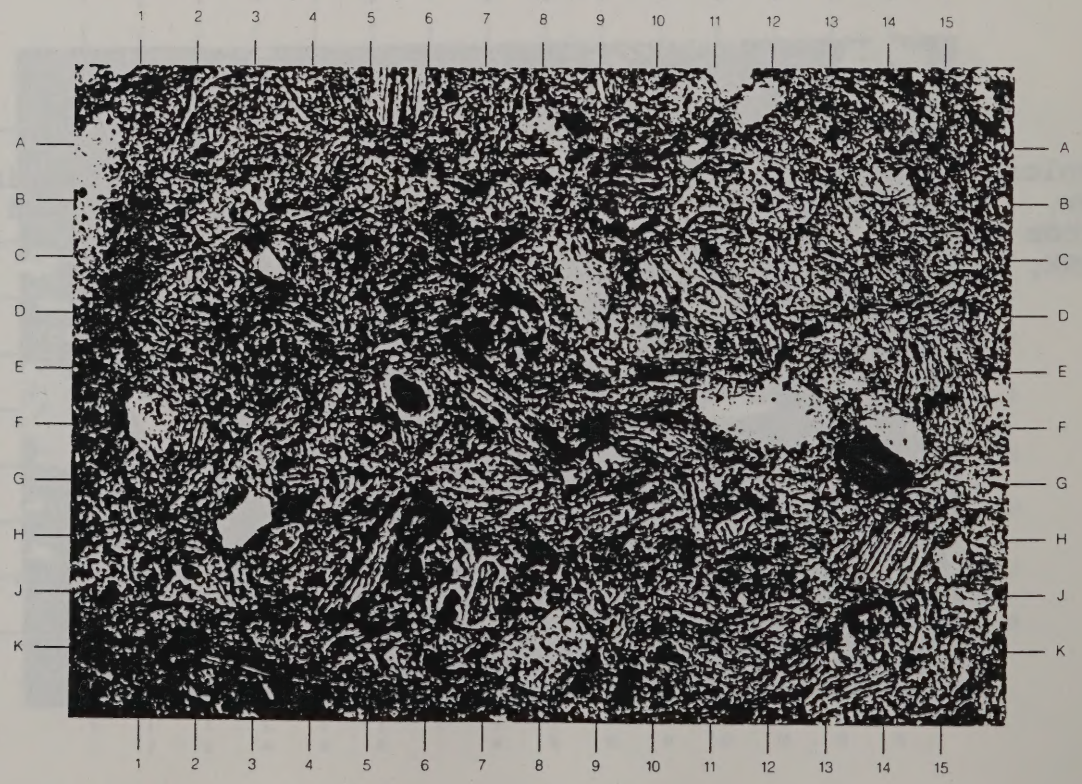
This photomicrograph provides a general overview of the sample, illustrating the large range in sizes of the constituents within the groundmass. Most of the constituents, which include rock fragments, crystals, and glass shards, are ash-size (less than 2 millimeters; A12), and less commonly, lapilli-size (between 2 and 64 millimeters; C0-9). (31X, plane-polarized light)

Plate 4B

A volcanic rock fragment within Sample No.32 is depicted in this view. This rock fragment consists of crystals (F12) and glass shards (B10.5) set in a groundmass of partially devitrified glass. (125X, plane-polarized light)


1 2 3 4 5 6 7 8 9 10 11 12 13 14 15
A B C D E F G H J K

A


1 2 3 4 5 6 7 8 9 10 11 12 13 14 15
A B C D E F G H J K

B

SAMPLE NO. 35

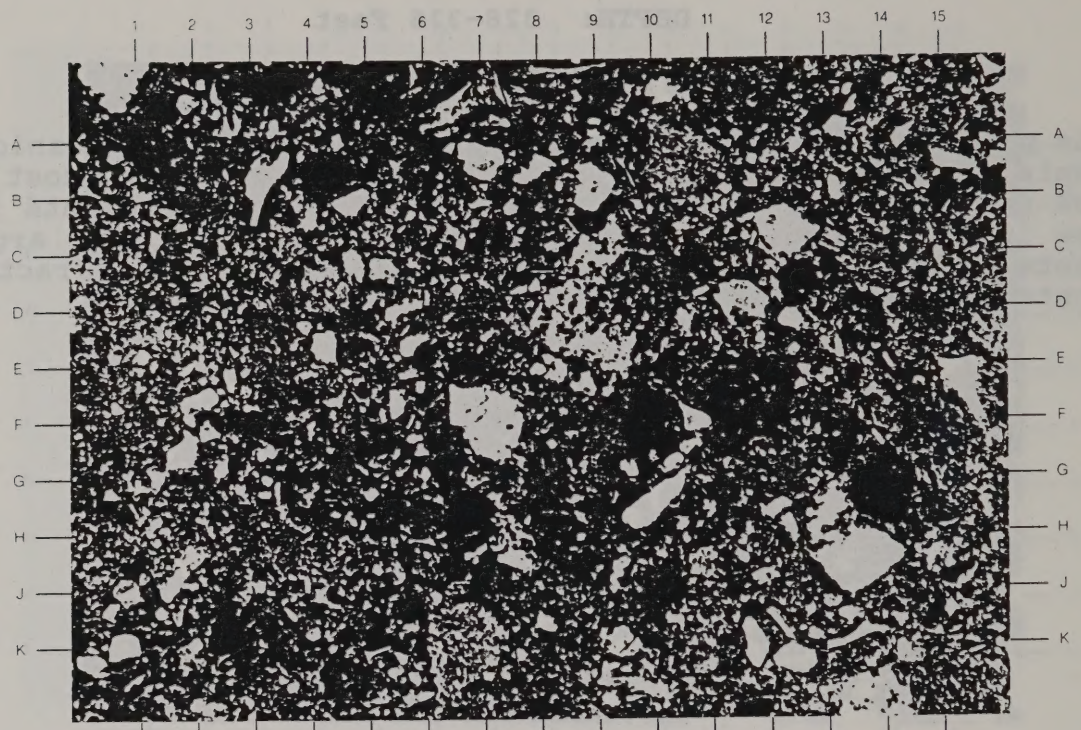
DEPTH: 328-338 Feet

PLATE 5A

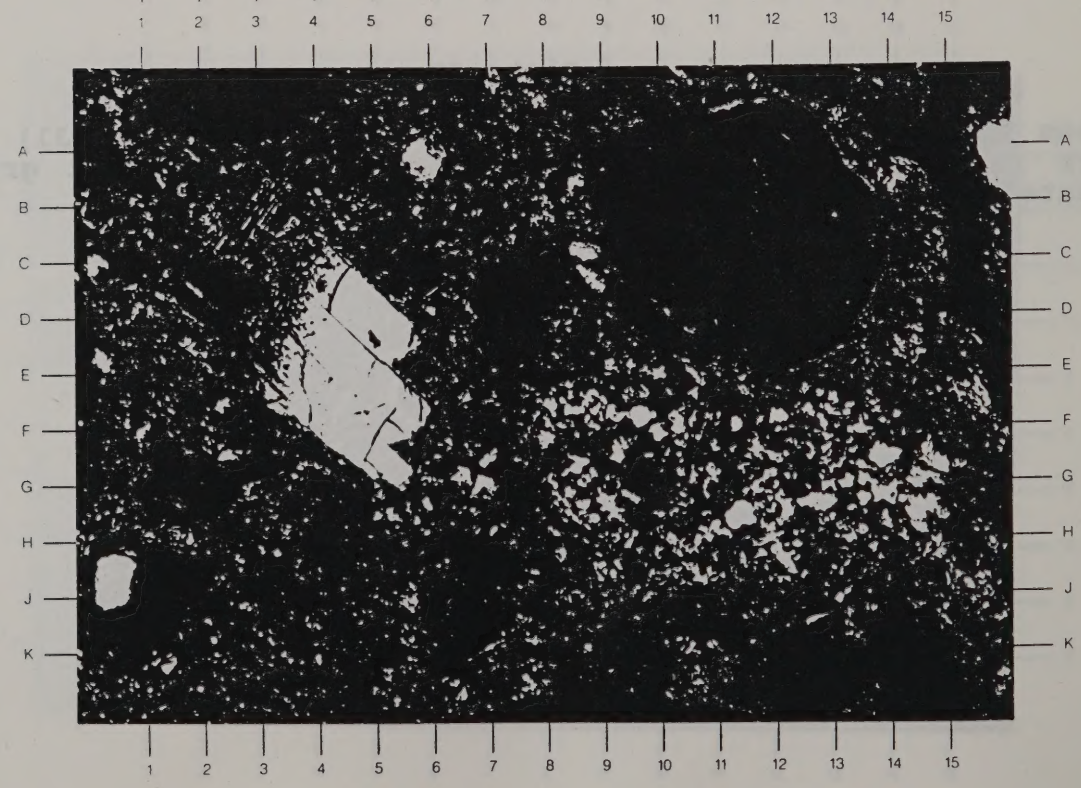
This photomicrograph displays a general overview of a volcaniclastic sample, a lapilli ash tuff. Silicate minerals comprise most of the rock fragments and crystals in this sample. Rock fragments in this view include chert (F7), volcanic rock fragments (A7-8), argillite clasts (F14, G4.5), and plagioclase (B9). An open fracture is located at K1-3. (31X, plane-polarized light)

Plate 5B

Glass shards (A15-E16) and vitric rock fragments (B11, J1) appear dark in this view under crossed polarizers. A chert grain is located at G9-15. (125X, crossed polarizers)


1 2 3 4 5 6 7 8 9 10 11 12 13 14 15
A B C D E F G H J K

A


1 2 3 4 5 6 7 8 9 10 11 12 13 14 15
A B C D E F G H J K

B

Western Atlas International
A Litton Dresser Company

CORE LABORATORIES

Special Core Analysis Study

for

WOODWARD-CLYDE CONSULTANTS
Oakland City Center
500 12th Street, Suite 100
Oakland, California 94607-4014

Final Report

File Number: SCAL-89027

Western Atlas International
A Litton/Dresser Company

CORE LABORATORIES

February 22, 1989

Woodward-Clyde Consultants
Oakland City Center
500 12th Street, Suite 100
Oakland, CA 94607-4014

Attention: John Thackston/Kelly Teague

Subject: Porosity Measurements
Hole #WCPW No. 1
File Number: SCAL-89027

Gentlemen:

Five unconsolidated sediment samples from the subject site were supplied by the Dallas Petrological Services Lab for effective porosity at overburden determinations. These measurements were performed in conjunction with a Petrographic study (PETR 189015) previously reported on February 7, 1989. Final results are enclosed.

The submitted material first was dried in a vacuum oven at 220°F for a period of 72 hours, then the grain density of a representative portion of each sample was determined using a calibrated matrix cup. This information was used to calculate the in-situ net stress (overburden) for each sample assuming the mean depth, 40 percent porosity, a water table at 190 feet, and a water density of 1.0 g/cc. Next, a known volume of each sediment sample was placed inside a rubber sleeve located within a pressure vessel, and the calculated triaxial stress applied. Lastly, helium was injected into each sample and the pore volume determined directly by gas expansion (Boyle's Law). Bulk volumes of the samples were obtained by adding the corresponding grain volumes and pore volumes. Porosities were determined from the measured pore volumes and calculated bulk volumes.

Test results are presented on the following page. Since the reconstituted samples are likely to have a higher porosity than the undisturbed in-situ samples, a second measurement was made at an arbitrarily chosen higher overburden pressure (500 psi). These additional measurements were performed at no charge.

1300 East Rochelle Boulevard, Irving, Texas 75062-3963 P.O. Box 152053, Irving, Texas 75015-2053, (214) 541-2673, (800) 248-CORE

Thank you for this opportunity to be of service. Please contact us if you have any questions about the enclosed data or if we may be of any additional service.

Very truly yours,

Michael W. Dann

Michael W. Dann, Laboratory Supervisor
Enhanced Oil Recovery
Dallas Core Services

MWD:BES:ed

Enclosure

This report, based on observations and materials supplied by the client, is prepared for the exclusive and confidential use by the client. The analyses, opinions, or interpretations contained herein represent the judgment of Core Laboratories; however, Core Laboratories and its employees assume no responsibility and make no warranties or representations as to the utility of this report to the client or as to the productivity, proper operation, or profitableness of any oil, gas, or other mineral formation or well in connection with which such report may be used or relied upon.

File: 89027

SUMMARY OF POROSITY DATA

Sample Number	Depth, ft.	Grain Density, g/cc	Calculated Overburden Stress, psi	Effective Porosity, % bulk volume @ Specified Stress	@ 500 psi Stress
23	208-218	2.56	144	35.2	30.7
26	238-248	2.55	170	37.6	34.5
29	268-278	2.55	195	36.2	33.5
32	298-308	2.54	220	35.6	33.0
35	328-338	2.53	244	35.7	33.6

APPENDIX I
WELL AND SPRING INVENTORY

SPRING/WELL NUMBER	ORIGINAL PERMITTED WELL OWNER	DRILLER	YEAR COMPLETED	ELEVATION (ft. MSL) 1/	DEPTH OF WELL (ft.)	CASING DATA			STATIC WATER LEVEL		PUMPING DATA				METHOD OF LIFT & POWER 5/	USE OF WATER 6/	WATER TEMPERATURE (F)	REMARKS
						DIAMETER (inches)	DEPTH INTERVAL (feet)	SLOTTED INTERVAL (feet)	DEPTH (ft.) 2/	DATE	RATE (gpm) 3/	LEVEL (ft.) 4/	SPECIFIC CAPACITY (gpm/ft)	DATE				
37-67-3dc	PAN-AMERICAN PETROLEUM	SIGNAL DRILLING CO.	1968	5890	5284	10	0-612	--	--	--	--	--	--	--	--	IND(U)	--	OIL TEST HOLE
37-69-1ac	WALTER BROWN	BOLEY, HENRY, WEECH	1962	4990	610	16 12	0-350 343-610	150-350 350-610	149R 130R 147.17	9/61 10/62 10/21/69	800R	250R	6.7	10/62	--	IRRIG	--	--
37-69-1cc	OSCAR PATTON	BURROUGHS ELECTRIC CO.	1962	4925	631	12 8	0-409 391-634	284-409 409-631	75R	11/62	1100R	250R	6.3	11/62	T,D	IRRIG	--	--
38-62-5ac	BRAD DALTON	R.D. REYNOLDS DRILLING	1981	5775	137	6	0-137	117-137	70R	7/81	15R	--	--	7/81	B	S	COOL	WELL BAILED 15GPM FOR 1 HR., 15FT OF DRAWDOWN OBSERVED
38-62-13da	VERN DALTON	ARMSTRONG BROS.	1977	5872	306	6	0-123	83-123	--	--	--	--	--	--	--	S	--	--
38-62-25	DARREL RYTTING	DARREL RYTTING	1959	5710	158	12	0-115	--	37R	5/59	450R	--	--	5/59	E,S	IRRIG	--	WELL CASED ONLY TO 115FT, OPEN HOLE TO TD. 8" 10 HP 450GPM ELEC. SUBMRSBLE PUMP INSTALLED.
38-62-25dd	ARLENE CRAIN	RALPH DENTON DRILLING CO.	1970	5640	172	10	0-172	135-172	53R	4/70	--	--	--	--	--	IRRIG	48	--
38-62-26c	RUSSEL WEEKS	C.E. ROBERTSON	1948	5726	118	5	0-118	95-118	78R	11/48	--	--	--	--	--	S	--	--
38-62-27bc	RUSSELL WEEKS	L. CLARKSON	1953	5910	312	6	0-312	243-300	127R	7/53	4R	--	--	--	--	S	--	WELL LOG STATES THAT "WELL MAKES 4GPM".
38-62-34ca	DALTON-REYNOLDS	ARMSTRONG BROS.	1977	5660	303	6	0-303	223-303	--	--	--	--	--	--	--	S	--	--
38-62-34cc	RUSSEL WEEKS	C.E. ROBERTSON	1948	5630	27	5	0-26	8-26	8R	11/48	--	--	--	--	--	S	--	--
38-62-36ac	GARY CAZETT	J.B. REYNOLDS DRILLING	1975	5700	100	8	0-100	65-100	50R	5/75	60R	--	--	6/75	B	D	COLD	WELL BAILED 60+GPM FOR 3HRS 20FT DRAWDOWN OBSERVED
38-62-36c	GEORGE RALPH	J.B. REYNOLDS DRILLING	1953	5700	107	6	0-107	--	60R	9/53	--	--	--	--	C	S	COLD	WELL HAS WINDMILL INSTALLED TO DRIVE 2-3/4" 10GPM CYLINDER PUMP
38-63-4ac	LEONARD HOPKINS	J.B. REYNOLDS DRILLING	1953	6040	208	10	0-159	20-158	14R	7/53	550R	--	--	--	--	IRRIG	COLD	WELL PUMPED 550 GPM FOR 3 HRS 80 FT DRAWDOWN OBSERVED
38-63-4bc	LEONARD HOPKINS	J.B. REYNOLDS DRILLING	1963	5940	320	16 12	0-167 163-320	30-314	10R	6/63	1250R	--	--	6/63	--	IRRIG	COLD	WELL TESTED AT 1250GPM, 200 FT OF DRAWDOWN OBSERVED
38-63-8aa	LEONARD HOPKINS	AVERY BLANCHARD	1949	5905	30	12	0-28	18-28	9R	8/49	--	--	--	--	--	IRRIG	--	WELL PRODUCED A SMALL AMOUNT OF WATER.
38-63-8c	LEONARD HOPKINS	J.B. REYNOLDS DRILLING	1954	5580	104	6	0-104	30-102	30R	8/54	55R	--	--	4/55	B	IRRIG	COLD	WELL BAILED AT 55GPM FOR 30MIN.

SPRING/WELL NUMBER	ORIGINAL PERMITTED WELL OWNER	DRILLER	YEAR COMPLETED	ELEVATION (ft. MSL) 1/	DEPTH OF WELL (ft.)	CASING DATA			STATIC WATER LEVEL		PUMPING DATA					METHOD OF LIFT & POWER 5/	USE OF WATER 6/	WATER TEMPERATURE (F)	REMARKS
						DIAMETER (inches)	DEPTH INTERVAL (feet)	SLOTTED INTERVAL (feet)	DEPTH (ft.) 2/	DATE	RATE (gpm) 3/	LEVEL (ft.) 4/	SPECIFIC CAPACITY (gpm/ft)	DATE					
38-63-8ca1	LEONARD HOPKINS	J.B. REYNOLDS DRILLING	1960	5580	210	16	0-206	28-194	29R	12/60	--	--	--	--	--	IRRIG	--	--	
38-63-8ca2	LEONARD HOPKINS	J.B. REYNOLDS DRILLING	1949	5580	40	6	0-40	30-40	16R	8/49	--	--	--	--	--	S,D	--	--	
38-63-17ab	LEONARD HOPKINS	O.M. JULLARD DRILLING CO.	1974	6040	150	12	0-150	0-150	12R	11/74	50R	--	--	11/74	B	IRRIG	--	WELL BAILED 50GPM FOR 8HRS, 140FT OF DRAWDOWN OBSERVED	
38-63-18da1	BRAD DALTON	R.D. REYNOLDS DRILLING	1981	5870	100	6	0-100	79-100	52R	8/81	15R	--	--	8/81	B	S	COLD	WELL BAILED 15GPM FOR 1HR, 5FT OF DRAWDOWN OBSERVED	
38-63-32	ALBERT GABLE	C.E. ROBINSON	1948	5775	57	8	0-52	14-52	15R	12/48	--	--	--	--	--	D	--	--	
38-63-33ad	ROBERT WRIGHT	W.H. MUTH	1965	5920	102	6	0-102	52-100	51R	7/65	30R	--	--	7/65	B	S	COLD	WELL BAILED 30GPM FOR 7?HRS, 14FT DRAWDOWN OBSERVED.	
38-63-33ca	ROBERT WRIGHT	GEORGE HASSAND	1961	5905	260	6	0-260	190-260	160R	5/61	--	--	--	--	--	S	COLD	--	
38-63-35	E.V. HOOD	RAY ROWDEN	1955	6170	179	6	0-50	20-50	20R	9/55	--	--	--	--	--	S	60	--	
38-64-20da	ROBERT WRIGHT	R.D. REYNOLDS DRILLING	1981	6170	356	6	0-356	295-356	165R	6/81	15R	--	--	6/81	B	S	COOL	WELL BAILED AT 15GPM FOR1HR, 20 FT DRAWDOWN OBSERVED	
38-64-21d	GEORGE RALPH	ROBERT BLANCHARD	1950	6135	276	6	0-276	256-276	251R 250.75	5/50 9/22/88	8R	--	--	6/50	B	S	48	WELL BAILED APPROX 8GPM, 7FT OF DRAWDOWN OBSERVED	
38-64-31cc	ROBERT WRIGHT	J.B. REYNOLDS DRILLING	1960	6135	307	6	0-307	227-307	220R	6/60	--	--	--	--	--	S	COLD	--	
38-65-10ab	PEQUOP SPRING	--	--	6260	--	--	--	--	FLOWING	9/88	1.4 GPM	--	--		--	S	15	--	
38-65-24bc	BIG SPRINGS RANCH	R.D. REYNOLDS DRILLING	1980	6825	300	6	0-300	260-300	240R	11/80	10R	--	--	11/80	B	S	47	WELL BAILED AT 10GPM FOR 3HRS, 10 FT DRAWDOWN OBSERVED	
38-65-24ca	KERN VALLEY PACKING	L. CLARKSON	1948	6800	245	6	0-245	185-235	190R 193.12	9/5/48 9/22/88	12R	190R	--	9/5/48	B	S	--	REPLACED BY WELL 38-65-24bc	
38-66-32ca	UNNAMED SPRING	--	--	7040	--	--	--	--	FLOWING	9/88	0.3 GPM	--	--	--	--	S	19	--	
38-67-29d	ARIZONA-COLORADO CATTLE CO.	HARRY BOLTON	1965	6055	792	6	621	550-620	--	--	--	--	--	--	--	S	--	--	
38-67-21aa	MESQUITE LAND CO.	ALBERT SMITH	1972	6380	224	2	0-21	0-21	--		--	--	--	--	--	S	46	HORIZONTAL WELL.	

SPRING/WELL NUMBER	ORIGINAL PERMITTED WELL OWNER	DRILLER	YEAR COM-PLETED	ELEVATION (ft. MSL) 1/	DEPTH OF WELL (ft.)	CASING DATA			STATIC WATER LEVEL		PUMPING DATA				METHOD OF LIFT & POWER 5/	USE OF WATER 6/	WATER TEM-PERATURE (F)	REMARKS
						DIAMETER (inches)	DEPTH INTERVAL (feet)	SLOTTED INTERVAL (feet)	DEPTH (ft.) 2/	DATE	RATE (gpm) 3/	LEVEL (ft.) 4/	SPECIFIC CAPACITY (gpm/ft)	DATE				
38-68-30	SOUTH. PACIF. CO.	--	1904	5775	541	12 6	0-343 0-472	-- 454-472	403R	1904	125R	--	--	1904	--	D	--	--
38-69-1bb	BONNIE SENNEFF	MUTH DRILLING CO.	1973	5180	505	6 5	0-410 245-505	330-400 400-505	285R	8/73	34R	--	--	1973	--	D	--	--
38-69-4ad	LS RANCHES, INC.	--	--	4952	180	6	--	--	109.18	4/19/81	--	--	--	--	C,D	S	--	--
38-69-5ba	GAMBLE RANCH DE-VELOPMENT CO.	BOLEY, HENRY, WEECH	1961	--	500	16	0-249	172-245	172R	7/61	--	--	--	--	--	--	59	WELL DRILLED FOR IRRIGATION PURPOSES, DID NOT PRODUCE SUFFICIENT WATER. WELL CAPPED BY DRILLER.
38-69-26cd	LS RANCHES, INC.	--	--	4950	170	6	0-170	--	--	--	--	--	--	--	C,D	S	--	--
39-62-29b	HARMON THURSTON	AVERY BLANCHARD	1952	5700	37	5	0-37	27-37	15R	8/52	30R	--	--	8/52	B	S	COLD	WELL BAILED 30GPM FOR ?? HRS, ?? DRAWDOWN
39-63-2	SILVER STATE CON-STRUCTION	J.B. REYNOLDS DRILLING	1953	6040	80	110	0-80	0-80	5R	5/53	--	--	--	--	--	I	COLD	--
39-63-10ab	--	--	--	--	--	--	--	--	--	--	--	--	--	--	--	S	--	--
39-64-1da	THURSTON SPRING	--	--		--	--	--	--	FLOWING	9/88	0.3 GPM	--	--	--	--	S	--	--
39-64-1aa	ROBERT KING	BOLEY, HENRY, WEECH	1983	6170	612	6 5	0-294 277-612	100-290 290-600	20R	9/83	20R	--	--	--	B	D	COLD	WELL BAILED 20GPM FOR 1 HR, 40 FT DRAWDOWN OBSERVED
39-64-11aa	UNNAMED SPRING	--	--	--	--	--	--	--	FLOWING	9/88	1.0 GPM	--	--	--	--	S	11	--
39-64-13dc	SHEEP SPRING	--	--	--	--	--	--	--	FLOWING	9/88	1.0 GPM	--	--	--	--	S	--	--
39-64-14ab	TRIPON PASS SP.	--	--	--	--	--	--	--	FLOWING	9/88	0.6 GPM	--	--	--	--	S	9	--
39-64-26ac1	UNNAMED SPRING	--	--	--	--	--	--	--	--	--	0.1 GPM	--	--	--	--	S	--	--
39-64-26ac2	UNNAMED SPRING	--	--	--	--	--	--	--	--	--	0.5 GPM	--	--	--	--	S	--	--
39-64-26ac4	UNNAMED SPRING	--	--	--	--	--	--	--	--	--	0.7 GPM	--	--	--	--	S	--	--
39-65-1	RON BAHLER	R.D. REYNOLDS DRILLING	1983	5700	410	--	--	--	202R	9/83	75R	--	--	9/83	A	T	COLD	WELL DRILLED AS TEST HOLE. WELL NOT CASED WELL AIR PUMPED 75GPM FOR ?? HRS.

SPRING/WELL NUMBER	ORIGINAL PERMITTED WELL OWNER	DRILLER	YEAR COM-PLETED	ELEVATION (ft. MSL) 1/	DEPTH OF WELL (ft.)	CASING DATA			STATIC WATER LEVEL		PUMPING DATA				METHOD OF LIFT & POWER 5/	USE OF WATER 6/	WATER TEM-PERATURE (F)	REMARKS
						DIAMETER (inches)	DEPTH INTERVAL (feet)	SLOTTED INTERVAL (feet)	DEPTH (ft.) 2/	DATE	RATE (gpm) 3/	LEVEL (ft.) 4/	SPECIFIC CAPACITY (gpm/ft)	DATE				
39-65-3aa	WINECUP RANCH	BOLEY, HENRY, WEECH	1968	5840	340	6	0-216	197-212	107R 105.05	9/68 10/11/88	5R	--	--	9/68	B	S	COLD	WELL BAILED 5GPM FOR 2.5HRS, 40 FEET DRAWDOWN.
39-65-13dd	SUN EXPLORATION CO	--	1982	5828	10932	--	--	--	--	--	--	--	--	--	--	--	--	OIL EXPLORATION TEST HOLE
39-65-14cd	LANDS OF SIERRA	R.D. REYNOLDS DRILLING	1982	5850	418	6	0-418	378-418	358R	10/3/82	15R	--	--	9/82	--	S	COLD	AIR PUMPED 15GPM FOR 4HRS, 50FT OF DRAWDOWN
39-65-21dc	L. DEADMAN SPRING	--	--	--	--	--	--	--	--	--	--	--	--	--	--	S	--	--
39-65-24ab	SIERRA PACIFIC RESOURCES	R.D. REYNOLDS DRILLING	1988	5831	600	6	0-508	380-490	315.79M	10/8/88	--	--	--	--	--	--	--	WOODWARD-CLYDE TEST WELL TW-14
39-65-27bab	SIERRA PACIFIC RESOURCES	R.D. REYNOLDS DRILLING	1988	5927	286	--	--	--	--	--	--	--	--	--	--	T	--	WOODWARD-CLYDE MONITORING WELL MW-5, PLUGGED & ABANDONED
39-65-30b	LS RANCHES, INC.	MUTH DRILLING CO.	1965	6170	70	6	0-70	30-67	29R 11.70	6/65 10/8/87	4R	32R	1.3	6/65	--	S	--	--
39-65-30c	MIRCUY RANCH	--	1965	6150	90	6	0-90	--	29R	6/65	4R	--	--	6/65	--	S	--	--
39-65-33cb	SUN EXPLORATION CO	--	1981	6128	14000	--	--	--	--	--	--	--	--	--	--	--	--	OIL EXPLORATION TEST HOLE
39-65-33cc	SUN EXPLORATION CO	B.B. GAILY	1981	6040	500	10	0-500	460-500	132R	11/28/81	--	--	--	--	--	IND(U)	COLD	WELL TO PROVIDE OIL WELL DRILLING RIG WITH WATER
39-65-33acc	SUN EXPLORATION CO	R.D. REYNOLDS DRILLING	1981	6040	303	6	0-303	186-207 224-244 262-283	108R	11/10/81	30R	--	--	11/81	--	IND(U)	COOL	WELL TO PROVIDE OIL WELL DRILLING RIG WITH WATER
39-65-33dd	MUD SPRING	--	--	--	--	--	--	--	FLOWING	9/88	3.0 GPM	--	--	--	--	S	--	--
39-66-5bc	SIERRA PACIFIC RESOURCES	R.D. REYNOLDS DRILLING	1988	5710	415	12	0-410	200-260 290-360 380-390	192.55	12/15/88	--	--	--	--	--	--	--	WOODWARD-CLYDE TEST WELL TW-3
39-66-5bc	SIERRA PACIFIC RESOURCES	R.D. REYNOLDS DRILLING	1988	5713	947	2	0-319	299-319	193.45	12/15/88	--	--	--	--	--	--	--	WOODWARD-CLYDE MONITORING WELL MW-3
39-66-9cb	SIERRA PACIFIC	R.D. REYNOLDS DRILLING	1988	5721	425	6	0-415	275-395	211.95	10/10/88	--	--	--	--	--	--	--	WOODWARD-CLYDE TEST WELL TW-15
39-66-16dc1	LS RANCHES, INC.	--	--	5759	280	8	--	--	159.6 150.23 150.30 150.34 151.25	4/18/81 6/1/85 10/8/86 10/6/87 12/9/88	--	--	--	--	C,W	S	--	--

SPRING/WELL NUMBER	ORIGINAL PERMITTED WELL OWNER	DRILLER	YEAR COMPLETED	ELEVATION (ft. MSL) 1/	DEPTH OF WELL (ft.)	CASING DATA			STATIC WATER LEVEL		PUMPING DATA				METHOD OF LIFT & POWER 5/	USE OF WATER 6/	WATER TEMPERATURE (F)	REMARKS
						DIAMETER (inches)	DEPTH INTERVAL (feet)	SLOTTED INTERVAL (feet)	DEPTH (ft.) 2/	DATE	RATE (gpm) 3/	LEVEL (ft.) 4/	SPECIFIC CAPACITY (gpm/ft)	DATE				
39-66-16dc2	LS RANCHES, INC.	R.D. REYNOLDS DRILLING	1985	5780	465	6	0-465	175-185 250-270 310-330 375-405 445-465	151R	2/85	4R	--	--	2/18	--	S	COLD	WELL BAILED 4GPM FOR 2HRS, 300FT DRAWDOWN
39-66-30bb	LS RANCHES, INC.	RALPH DENTON DRILLING CO.	--	5955	460	6	0-460	410-450	403R	9/69	10R	--	--	9/69	S,E	S	58	--
39-67-3dc	MESQUITE LAND CO.	ALBERT SMITH	1972	7200	125	2	0-125	104-125	--	--	--	--	--	--	--	S	46	HORIZONTAL WELL.
39-67-10ac	NORTH SPRING	--	--	--	--	--	--	--	FLOWING	9/88	0.4 GPM	--	--	--	--	S	10	--
39-67-15bb	LEWIS SPRING	--	--	--	--	--	--	--	FLOWING	9/88	0.3 GPM	--	--	--	--	S	12	--
39-67-15dd	LAWRENCE & STEGALL	HARRY BOLTON	1964	6560	203	6	0-203	100-203	88R	4/64	--	--	--	--	--	S	--	--
39-67-16bb	MESQUITE LAND CO.	ALBERT SMITH	1972	5775	103	2	0-103	62-103	--	--	--	--	--	--	--	S	46	HORIZONTAL WELL.
39-67-18ad	WELL	--	--	--	--	6	--	--	44.83 44.20 43.84	10/6/87 12/15/87 2/25/88	--	--	--	--	--	S	--	--
39-67-21aa	MESQUITE LAND CO.	ALBERT SMITH	1972	--	224	2	0-22	0-22	--	--	--	--	--	--	--	S	46	HORIZONTAL WELL
39-67-21ac	--	--	--	--	--	6	--	--	18.50	10/12/88	--	--	--	--	--	S	--	--
39-67-22bb	--	--	--	--	--	--	--	--	--	--	--	--	--	--	--	S(U)		
39-68-1cd	LAWRENCE & STEGALL	HARRY BOLTON	1964	5050	300	6	0-300	200-300	155R	6/64	--	--	--	--	--	S	--	--
39-68-7ab	MONTELLO SPRINGS	--	--	--	--	--	--	--	FLOWING	9/88	400 GPM	--	--	--	--	MUNICIP.	10	PROVIDES PARTIAL WATER SUPPLY TO TOWN OF MONTELLO
39-68-8bb	NEAR MONTELLO SPRS	--	--	--	--	--	--	--	FLOWING	9/88	0.75 GPM	--	--	--	--	S	10	--
39-68-10bb	LAWRENCE & STEGALL	HARRY BOLTON	1964	5450	501	6	0-501	390-501	390R	4/64	--	--	--	--	--	S	--	--
39-68-21dd	LAWRENCE & STEGALL	HARRY BOLTON	1964	5350	555	6	0-556	475-550	456R 420.42	4/64 10/12/88	--	--	--	--	--	S	--	--
39-68-25ad	R.S. HAGEN	W.H. MUTH	1971	4990	158	6	0-159	118-157	105R	4/71	30R	--	--	4/71	B	D	58	WELL BAILED 30GPM FOR 2HRS, NO DRAWDOWN OBSERVED.
39-68-25db	CATHY MOSES	R.D. REYNOLDS DRILLING	1981	--	300	6	0-300	188-207 263-300	105R	11/81	50R	--	--	11/81	A	D, IRRIG	COLD	WELL AIR PUMPED AT 50 GPM., BAILED AT 15GPM FOR 1HR, 8 FT OF DRAWDOWN

SPRING/WELL NUMBER	ORIGINAL PERMITTED WELL OWNER	DRILLER	YEAR COMPLETED	ELEVATION (ft. MSL) 1/	DEPTH OF WELL (ft.)	CASING DATA			STATIC WATER LEVEL		PUMPING DATA				METHOD OF LIFT & POWER 5/	USE OF WATER 6/	WATER TEMPERATURE (F)	REMARKS
						DIAMETER (inches)	DEPTH INTERVAL (feet)	SLOTTED INTERVAL (feet)	DEPTH (ft.) 2/	DATE	RATE (gpm) 3/	LEVEL (ft.) 4/	SPECIFIC CAPACITY (gpm/ft)	DATE				
39-69-3ad	ANDY MCDERMOTT	R.D.REYNOLDS DRILLING	1979	4816	120	8	0-120	12-115	10R	7/79	60R	15R	12	1979	S,E	IND	--	--
39-69-5ab	JOHN KREMER	R.D.REYNOLDS DRILLING	1978	4890	239	8	0-239	55-234	76R	5/78	75R	--	--	5/78	--	IRRIG	--	--
39-69-9ca	MELVIN MAY	R.D. REYNOLDS DRILLING	1982	--	105	6	0-105	85-105	20R	4/82	30+R	--	--	4/82	B	D	COLD	WELL BAILED 30+GPM FOR 3 HRS, 30 FT OF DRAWDOWN OBSERVED
39-69-17a	ALLEN JONES	R.D. REYNOLDS DRILLING	1986	--	320	--	--	--	--	--	--	--	--	--	--	D	--	WELL PLUGGED AND ABANDONED
39-69-19aa	LIONEL FOURNIER	W.H. MUTH	1973	--	163	6	0-163	120-160	70R	6/73	35R	--	--	6/73	B	D	60	WELL BAILED AT 35GPM FOR 3HRS, 20 FT OF DRAWDOWN OBSERVED.
39-69-19bd	JOHN GILLINGHAM	J.B. REYNOLDS	--	4890	650	8	0-180	105-175	70R	9/74	25R	170R	0.25	1974	--	D	--	WELL DRILLED TO 650 FEET,COMPLETED AT 180 FEET. DRILLERS LOG STATES NO WATER ENCOUNTERED BELOW 230 FEET.
39-69-20cd	GERALD LEE	R.D.REYNOLDS DRILLING	1978	4900	431	16	0-431	25-431	70R	3/78	480R	--	4	1978	T,D	IRRIG	--	--
39-69-22bb	GERALD LEE	MUTH DRILLING CO.	1973	--	170	6	0-170	--	70R	6/73	35R	--	--	1973	B	D	60	WELL BAILED AT 35GPM FOR 2.5HRS, 15 FT OF DRAWDOWN
39-69-31ac	ADAM ZABROWSKI	MUTH DRILLING CO.	1975	--	190	6	0-190	165-190	150R	10/75	25R	--	--	10/75	B	D	COLD	WELL BAILED AT 25GPM FOR 3HRS, 7 FT OF DRAWDOWN OBSERVED
39-69-31ad	S.C. HAGER	MUTH DRILLING CO.	1971	4990	240	10 7	0-50 50-240	200-240 --	150R	4/71	34R	--	0.6R	4/71	--	D	58	--
39-69-34dd	NORMAN LUDWIG	R.D. REYNOLDS DRILLING	1978	--	126	8	0-126	86-126	50R	5/78	35R	--	--	5/78	B	D	48	WELL BAILED AT 35 GPM FOR 4HRS, 45 FT OF DRAWDOWN OBSERVED.
40-62-12d	UNNAMED SPRING	--	--	--	--	--	--	--	--	--	8.0 GPM	--	--	--	--	S	14	--
40-63-1d	WINECUP RANCH	BOLEY, HENRY, WEECH	1968	6280	210	6	0-209	23-29	21R	5/68	10R	--	--	5/68	B	S	54	WELL BAILED 10GPM FOR 3HRS, REPORTED 8 FEET OF DRAWDOWN.
40-63-2ac	UNNAMED SPRING	--	--	--	--	--	--	--	--	--	0.2 GPM	--	--	--	--	U	17	--
40-63-10bd	UNNAMED SPRING	--	--	--	--	--	--	--	--	--	SEEP	--	--	--	--	U	23	--
40-63-12aa	ARNOLD & ASSOC.	ELSING DRILLING	1980	5970	355	8 6	0-250 245-250	55-345	18R	11/80	--	--	--	--	--	IND(U)	--	--
40-63-12ab	LS RANCHES, INC.	--	--	5970	190	6	0-190	--	~20.0	10/88	--	--	--	--	E	S	--	--

SPRING/WELL NUMBER	ORIGINAL PERMITTED WELL OWNER	DRILLER	YEAR COMPLETED	ELEVATION (ft. MSL) 1/	DEPTH OF WELL (ft.)	CASING DATA			STATIC WATER LEVEL		PUMPING DATA				METHOD OF LIFT & POWER 5/	USE OF WATER 6/	WATER TEMPERATURE (F)	REMARKS
						DIAMETER (inches)	DEPTH INTERVAL (feet)	SLOTTED INTERVAL (feet)	DEPTH (ft.) 2/	DATE	RATE (gpm) 3/	LEVEL (ft.) 4/	SPECIFIC CAPACITY (gpm/ft)	DATE				
40-63-12ac	ARNOLD & ASSOC.	ELSING DRILLING	1980	5970	180	8 6	0-127 124-180	60-175	10R 20	12/80 10/88	--	--	--	--	--	IND(U)	--	--
40-63-12cc	ARNOLD & ASSOC.	ELSING DRILLING	1981	6230	143	6	0-143	55-140	15R FLOWING	1/81 10/88	--	--	--	--	--	IND(U)	--	--
40-63-15acc	J.W. GATTSHALL	R.D. REYNOLDS DRILLING	1980	6560	112	8	0-112	95-112	95R	9/80	20R	--	--	--	--	S	COLD	WELL BAILED 20GPM FOR 3HRS, REPORTED 0 FEET OF DRAWDOWN
40-63-18bb	2MI. NW SUMMERCAMP	--	--	--	--	--	--	--	FLOWING	9/88	20.0 GPM	--	--	--	--	U	14	--
40-63-21ac	LEDGE SPRING	--	--	--	--	--	--	--	FLOWING	9/88	0.2 GPM	--	--	--	--	S	16	--
40-63-35ab	WINECUP RANCH	HARRY BOLTON	1958	6060	275	6	0-268	60-268	44R	6/58	--	--	--	--	--	S	--	--
40-63-35cc	WINECUP RANCH	WINECUP RANCH	1957	6030	220	6	0-110	--	35R	2/57	--	--	--	--	--	S	--	WELL DRILLED BY RANCH EMPLOYEES. UNCASED BELOW 110FT.
40-64-3ab	LS RANCHES, INC.	--	--	5624	122	12	--	--	23.43 16.80	4/17/81 9/19/88	800E	--	--	1/80	T	IRRIG	--	WELL HAS TURBINE PUMP INSTALLED, BUT NO POWER UNIT.
40-64-4b	BRUSH CREEK WELL	--	--	5700	--	--	--	--	83.55R	6/67	--	--	--	--	--	S	--	--
40-64-5ad	LS RANCHES, INC.	--	--	5745	220	6	0-220	--	--	--	--	--	--	--	C,W	S	--	--
40-64-16cc	UNNAMED SPRING	--	--	--	--	--	--	--	FLOWING	9/88	6.0 GPM	--	--	--	--	U	--	--
40-64-21da	BRUSH CREEK SP.	--	--	--	--	--	--	--	FLOWING	9/88	>500 GPM	--	--	--	--	S	19	--
40-64-21db	PRATHER SPRING	--	--	--	--	--	--	--	FLOWING	9/88	20 GPM	--	--	--	--	S	19	--
40-64-23d	WINECUP RANCH	W.H. MUTH	1965	6040	450	6	0-382	185-378	70R	3/65	7R	322R	--	3/65	B	S	--	WELL BAILED 7GPM, DRAWDOWN DATA NOT RECORDED.
40-65-2ab1	SIERRA-PACIFIC	WOODWARD-CLYDE	1981	5515	180	4	0-164.5	--	42.67	2/16/89	--	--	--	--	--	T	--	WOODWARD-CLYDE PIEZOMETER C10
40-65-2ab2	SIERRA-PACIFIC	WOODWARD-CLYDE	1981	5515	81	4	0-81	--	42.24	2/16/89	--	--	--	--	--	T	--	WOODWARD-CLYDE PIEZOMETER C11
40-65-2ab3	SIERRA-PACIFIC	WOODWARD-CLYDE	1981	5515	40	4	0-40	--	DRY	2/16/89	--	--	--	--	--	T	--	WOODWARD-CLYDE PIEZOMETER C12
40-65-6ac	INDIAN SPRING	--	--	--	--	--	--	--	FLOWING	9/88	2.0 GPM	--	--	--	--	S	13	--

SPRING/WELL NUMBER	ORIGINAL PERMITTED WELL OWNER	DRILLER	YEAR COMPLETED	ELEVATION (ft. MSL) 1/	DEPTH OF WELL (ft.)	CASING DATA			STATIC WATER LEVEL		PUMPING DATA				METHOD OF LIFT & POWER 5/	USE OF WATER 6/	WATER TEMPERATURE (F)	REMARKS
						DIAMETER (inches)	DEPTH INTERVAL (feet)	SLOTTED INTERVAL (feet)	DEPTH (ft.) 2/	DATE	RATE (gpm) 3/	LEVEL (ft.) 4/	SPECIFIC CAPACITY (gpm/ft)	DATE				
40-65-10ca1	SUN EXPLORATION	ELSING DRILLING	1983	5480	660	8 6	0-61 0-659	580-600 620-640	147R 140.53 140.30 140.20 140.28 140.31 140.32	11/83 6/7/85 3/7/86 2/11/87 10/7/87 12/8/87 2/25/88	30R	--	--	11/83	S	IND(U)	--	WELL DRILLED TO SUPPLY WATER TO OIL WELL DRILLING RIG. WELL PUMPED 30GPM FOR ??HRS.
40-65-10ca2	SUN EXPLORATION	SUN EXPLORATION	1983	5480	--	--	--	--	--	--	--	--	--	--	--	IND(U)	--	OIL EXPLORATION WELL
40-65-23cb	SIERRA-PACIFIC RESOURCES	R.D.REYNOLDS DRILLING	1988	5663	607	2	0-310	270-290	179.95	10/7/88	--	--	--	--	--	--	--	WOODWARD-CLYDE MONITORING WELL MW-2
40-65-24bd1	LS RANCHES, INC.	--	--	5589	160	8	--	--	97.67	6/20/67	--	--	--	--	C,W	S	--	--
40-65-24bd2	LS RANCHES, INC.	R.D.REYNOLDS DRILLING	1981	5589	185	6	0-185	146-185	108.0	11/14/81	15R	--	--	11/81	--	D(U)	--	--
40-65-26d	--	--	--	--	--	6	--	--	175.21 175.11 175.01	10/7/87 12/15/87 2/25/88	--	--	--	--	--	(U)	--	--
40-65-27a	KENNETH ALLEN	M.W. ELLIS	1979	5690	320	6	0-320	280-320	180R	6/79	120E	--	--	6/79	--	D(U)	56	--
40-65-27b	KENNETH ALLEN	M.W. ELLIS	1979	5720	317	6	0-300	280-300	220R	5/79	60E	--	--	5/79	--	D(U)	56	--
40-65-27c	KENNETH ALLEN	M.W. ELLIS	1979	5720	420	6 --	0-401 --	340-360 380-400	230R	6/79	25E	--	--	6/79	--	D(U)	56	--
40-65-27d	KENNETH ALLEN	M.W. ELLIS	1979	5690	437	6	0-397	376-396	210R 206.50	5/79 12/10/88	25E	--	--	5/79	--	U	56	--
40-65-31bb	GEORGE LENAROS	BOLEY, HENRY	1983	6300	200	6	0-200	170-180	52R	10/83	6R	--	--	10/79	B	D	COLD	WELL BAILED 6GPM FOR 4HRS, 50 FT OF DRAWDOWN OBSERVED.
40-65-34cd	LS RANCHES, INC.	R.D. REYNOLDS DRILLING	1986	5775	405	6	0-405	385-405	313R	5/86	10R	--	--	5/86	A	S	COLD	WELL AIR PUMPED AT 10GPM FOR 3HRS, 80 FT DRAWDOWN.
40-65-35aa	KENNETH ALLEN	M.W. ELLIS	1979	5680	300	6	0-298	278-298	220R 175.80	5/79 4/18/81	60E	--	--	1979	--	D(U)	56	--
40-65-35b	KENNETH ALLEN	M.W. ELLIS	1979	5720	317	6	0-309	287-307	240R	5/79	120E	--	--	1979	--	D(U)	56	--
40-65-35c	KENNETH ALLEN	M.W. ELLIS	1979	5720	300	6	0-285	265-285	200R	5/79	120E	--	--	1979	--	D(U)	56	--
40-65-35d	KENNETH ALLEN	M.W. ELLIS	1979	5690	300	6	0-297	275-295	180R	5/79	120E	--	--	1979	--	D(U)	54	--

SPRING/WELL NUMBER	ORIGINAL PERMITTED WELL OWNER	DRILLER	YEAR COM-PLETED	ELEVATION (ft. MSL) 1/	DEPTH OF WELL (ft.)	CASING DATA			STATIC WATER LEVEL		PUMPING DATA				METHOD OF LIFT & POWER 5/	USE OF WATER 6/	WATER TEM-PERATURE (F)	REMARKS
						DIAMETER (inches)	DEPTH INTERVAL (feet)	SLOTTED INTERVAL (feet)	DEPTH (ft.) 2/	DATE	RATE (gpm) 3/	LEVEL (ft.) 4/	SPECIFIC CAPACITY (gpm/ft)	DATE				
40-66-8cd1	LS RANCHES, INC.	--	--	5650	430	6	--	--	169.60	4/18/81	15E	--	--	4/18/81	C,D	S	61	--
40-66-8cd2	GULF REFINING CO.	KERR-MCGEE OIL, INC.	1954	5663	8412	10	0-543	--	--	--	--	--	--	--	--	U	--	OIL & GAS TEST WELL
40-66-24	GAMBLE RANCHES INC	BOLEY, HENRY, WEECH	1956	5900	200	6	0-200	145-155	98R 160.09 159.98 160.16	8/56 10/6/87 12/15/87 2/25/88	--	--	--	--	--	S	--	--
40-66-24dd	LS RANCHES, INC.	R.O. REYNOLDS DRILLING	1981	5950	185	6	0-185	146-185	100R 110.00	11/81 9/88	15R	--	--	11/3/81	B	S	COOL	WELL BAILED 15GPM FOR 1HR, 18FT DRAWDOWN OBSERVED
40-67-2cd	LS RANCHES, INC.	HARRY BOLTON	1963	5900	600	6	0-600	432-600	432R 440.45	11/63 10/6/88	10R	--	--	11/63	C	S	--	--
40-67-8ab	SIERRA-PACIFIC RESOURCES	R.D.REYNOLDS DRILLING	1988	5750	600	2	0-320	300-320	DRY	2/3/89	--	--	--	--	--	--	--	WOODWARD-CLYDE MONITORING WELL MW-16
40-67-16c	BUREAU OF LAND MANAGEMENT	BUREAU OF LAND MANAGEMENT	1942	5900	510	--	--	--	374.20 373.55 372.70	10/6/87 12/15/87 10/6/88	--	--	--	--	--	--	--	
40-67-26dc	LS RANCHES, INC.	--	--	--	--	6	--	--	--	--	--	--	--	--	--	--	--	--
40-67-28ad	LS RANCHES, INC.	HARRY BOLTON	1963	6500	700	6	0-601	476-700	357R 373.10	10/63 2/25/88	8R	--	--	10/63	--	S	--	--
40-67-31-1	GAMBLE RANCHES INC	BOLEY, HENRY, WEECH	1956	6100	615	--	--	--	38.5	9/88	--	--	--	--	--	--	--	DRY HOLE
40-67-31-2	GAMBLE RANCHES INC	BOLEY, HENRY, WEECH	1956	6100	250	--	--	--	--	--	--	--	--	--	--	--	--	DRY HOLE
40-67-32bb	LS RANCHES, INC.	R.O. REYNOLDS DRILLING	1986	--	77	6	0-77	52-62	33R 36.10 35.96 35.89 41.60	5/86 10/8/87 12/15/87 2/25/88 10/6/88	20R	--	--	5/86	C	S	COLD	WELL BAILED AT 20GPM FOR 4HRS, 5 FT OF DRAWDOWN OBSERVED. 3" CYLINDER PUMP SET AT 63 FT.
40-67-36cb	HOPPIE BASIN SP.	--	--	6700	--	--	--	--	--	--	--	--	--	--	--	S	--	--
40-68-25bb	LS RANCHES, INC.	C.D. LIPPINCOTT	1962	5330	450	16	0-450	350-450	338.75R 342.13	1962 10/12/88	--	--	--	--	--	U	--	WELL REPORTED TO PUMP DRY IN 15 MINUTES, WITH SLOW RECOVERY FOLLOWING PUMPING

SPRING/WELL NUMBER	ORIGINAL PERMITTED WELL OWNER	DRILLER	YEAR COMPLETED	ELEVATION (ft. MSL) 1/	DEPTH OF WELL (ft.)	CASING DATA: DIAMETER (inches)	CASING DATA: DEPTH INTERVAL (feet)	CASING DATA: SLOTTED INTERVAL (feet)	STATIC WATER LEVEL: DEPTH (ft.) 2/	STATIC WATER LEVEL: DATE	PUMPING DATA: RATE (gpm) 3/	PUMPING DATA: LEVEL (ft.) 4/	PUMPING DATA: SPECIFIC CAPACITY (gpm/ft)	PUMPING DATA: DATE	METHOD OF LIFT & POWER 5/	USE OF WATER 6/	WATER TEMPERATURE (F)	REMARKS
40-68-25ac	--	--	--	--	--	--	--	--	--	--	--	--	--	--	--	--	--	--
40-69-8bc	GAMBLE SPRING	--	--	--	--	--	--	--	FLOWING	9/88	400 GPM	--	--	--	--	S,D	21	--
40-69-13dcd	LS RANCHES, INC.	BOLEY, HENRY, WEECH	1956	4801	53	6	0-53	11-47	7R 7.30	1956 10/14/88	--	--	--	--	C,W	S	--	--
40-69-14bb	LS RANCHES, INC.	R.D. REYNOLDS DRILLING	1983	4840	60	6	0-60	50-60	+2R	1983	500R	--	--	7/83	A	S	62	WELL WAS ARTESIAN AT TIME. WATER LEVEL +2FT ABO TOP OF CASING, FLOW IS APPROX. 5GPM. WELL TESTED BY AIR PUMPING AT 500GPM FOR 4HRS, 20FT DRAWDOWN OBSERVED.
40-69-14cb	LS RANCHES, INC.	A.E. HOSACK & SON	1955	4818	542	16	0-72	8-66	2.5R	1955	680R	--	10.5R	1955	--	U	--	ABANDONED AND SEALED
40-69-14cd	LS RANCHES, INC.	ARNOLD ELSING	1980	4817	205	16	0-205	23-205	6.87 5.65 9R	4/16/81 11/14/81 10/7/81	1500R 1280R 1400R	65R 12.1M 24R	26.3 200 93	1980 11/14/81 10/07/81	T,E	IRRIG	72 65	--
40-69-15dd	LS RANCHES, INC.	ARNOLD ELSING	1980	4822	203	16	0-203	95-203	7.48 4.05	4/15/81 10/14/88	937R	42R	34.7	8/8/80	--	U	--	WELL MAY BE USED IN FUTURE
40-69-16cc	MESQUITE LAND CO.	BOLEY, HENRY, WEECH	--	--	200	16	0-144	11-34 60-65	--	--	--	--	--	--	--	IRRIG	--	--
40-69-16cac	LS RANCHES, INC.	BOLEY, HENRY, WEECH	--	4854	--	16	--	--	--	--	300R	--	--	--	T,E	U	57	--
40-69-16cad	LS RANCHES, INC.	BOLEY, HENRY, WEECH	1956	4860	58	20 16	0-53 53-58	23-43 --	7.8	4/19/81	--	--	--	--	T,E	U	55	--
40-69-16cbd	LS RANCHES, INC.	BOLEY, HENRY, WEECH	--	4857	120	16	--	--	5R 5.17 11.10	2/26/81 4/16/81 11/13/81	990R 1130R 1209R 900M	60R 80R 100R --	18 -- -- --	2/26/81 2/26/81 2/26/81 11/13/81	T,E	IRRIG	52	CASCADING WATER CAN BE HEARD WHILE WELL IS PUMPING. YIELD REPORTED TO DECREASE DURING 1981 IRRIGATION SEASON.
40-69-16ccb	LS RANCHES, INC.	BOLEY, HENRY, WEECH	1956	4851	210	16	0-38	2-38	0.5R	1956	2000R	15R	138	1956	T,E	IRRIG	76	DEPTH TO WATER REPORTED TO BE 98 FEET IN 1977 WHEN SOUNDED BY LAYNE PUMP COMPANY PERSONNEL.
40-69-19aa	GAMBLE RANCHES INC	L. CLARKSON	1950	5019	46	6	0-46	9-24	9R	12/50	17R	--	--	12/50	B	S	--	WELL BAILED 17GPM FOR ??HRS, ?? DRAWDOWN
40-69-21ab	LS RANCHES, INC.	R.D. REYNOLDS DRILLING	1986	4726	150	6	--	--	10R 14.70	7/86 ✓ 10/14/88	--	--	--	--	--	T	COLD	WELL WAS DRILLED AS TEST HOLE ONLY, CASING NOT INSTALLED

SPRING/WELL NUMBER	ORIGINAL PERMITTED WELL OWNER	DRILLER	YEAR COM-PLETED	ELEVATION (ft. MSL) 1/	DEPTH OF WELL (ft.)	CASING DATA			STATIC WATER LEVEL		PUMPING DATA				METHOD OF LIFT & POWER 5/	USE OF WATER 6/	WATER TEM-PERATURE (°F)	REMARKS
						DIAMETER (inches)	DEPTH INTERVAL (feet)	SLOTTED INTERVAL (feet)	DEPTH (ft.) 2/	DATE	RATE (gpm) 3/	LEVEL (ft.) 4/	SPECIFIC CAPACITY (gpm/ft)	DATE				
40-69-22bc	LS RANCHES, INC.	BOLEY, HENRY, WEECH	1956	4832	350	16	0-246	20-34	0.5R	1956	800-1000E	--	--	4/15/81	T,E	IRRIG	63	--
						--	--	89-180	8.25	4/15/81	1040M	40.9M	30.9	11/15/81				
									7.35	11/15/81								
40-69-23ad1	LS RANCHES, INC.	R.C. DENTON DRILLING CO.	1967	4807	189	16	0-160	--	12R	1967	--	--	--	--	--	U	--	WELL REPORTED ABANDONED DUE TO INSUFFICIENT YIELD.
40-69-23ad2	LS RANCHES, INC.	R.C. DENTON DRILLING CO.	1967	4910	320	16	0-311	--	15R	1967	--	--	--	--	--	U	--	DRY HOLE
40-69-23db	LS RANCHES, INC.	W.F. OSBORNE	1955	4818	274	16	0-120	--	9R	1955	2250R	--	--	1955	T,E	IRRIG	62	--
						14	115-175	126-172	7R	2/26/81	860R	40R	26	2/26/81				
									8.73	4/15/81	1150R	120R	--	2/26/81				
									8.50	11/15/81	700E	42.8M	20	11/15/81			57	--
40-69-25	LS RANCHES, INC.	BOLEY, HENRY, WEECH	1956	--	188	16	0-188	--	12R	1956	--	--	--	--	--	U	59	--
									6.40	10/14/88								
40-69-27ba	LS RANCHES, INC.	BOLEY, HENRY, WEECH	1956	4826	173	16	0-173	16-23	FLOWING(R)	1956	1150R	27R	67.7	8/7/80	T,E	IRRIG(U)	71	--
						--	--	130-143	7.63	4/19/81	1810R	46R	--	8/7/80				
											1400E	--	--	4/16/81				
40-69-28ac	LS RANCHES, INC.	BOLEY, HENRY, WEECH	1956	4828	200	16	0-74	11-34	12R	1956	--	--	--	--	--	U	--	WELL ABANDONED & SEALED
						--	--	60-65	10.10	10/14/88								
40-69-34baa	KAY KIMBER	J.F. O'BRIAN	1954	4821	311	16	0-54	--	9R	1954	--	--	--	--	T	S	--	--
40-69-34bda	GRAHAM KIMBER	G.K. KIMBER	1960	4821	32	16	0-32	0-32	5.5R	1960	960R	27R	36	1960	--	U	64	--
									7.10R	4/16/81								
40-69-36dc	--	--	--	--	--	6	--	--	14.35	10/14/88	--	--	--	--	--	(U)	--	--
41-62-36ca	UNNAMED SPRING	--	--	6300	--	--	--	--	--	--	--	--	--	--	--	U	--	--
41-63-1bc1	UNNAMED SPRING	--	--	--	--	--	--	--	--	--	--	--	--	--	--	--	--	--
41-63-1bc2	UNNAMED SPRING	--	--	--	--	--	--	--	--	--	--	--	--	--	--	--	--	--
41-63-10c	UNION PACIFIC R.R.	--	--	--	92	6	--	--	3.96R	6/50	20R	--	--	--	--	D	--	--
41-64-8dd	LS RANCHES, INC.	--	--	5770	130	6	--	--	78.10	4/18/81	--	--	--	--	S,E	U	--	--
									78.33	10/17/88								
41-64-20aa	DERRAL CHRISTENSEN	HERALD PETERSON	1979	5700	500	12	0-368	310-320	70R	1979	600R	--	--	1979	--	U(IRRIG)	50	--
									62.80	4/18/81	200R	--	--	12/79				

SPRING/WELL NUMBER	ORIGINAL PERMITTED WELL OWNER	DRILLER	YEAR COMPLETED	ELEVATION (ft. MSL) 1/	DEPTH OF WELL (ft.)	CASING DATA			STATIC WATER LEVEL		PUMPING DATA				METHOD OF LIFT & POWER 5/	USE OF WATER 6/	WATER TEMPERATURE (F)	REMARKS
						DIAMETER (inches)	DEPTH INTERVAL (feet)	SLOTTED INTERVAL (feet)	DEPTH (ft.) 2/	DATE	RATE (gpm) 3/	LEVEL (ft.) 4/	SPECIFIC CAPACITY (gpm/ft)	DATE				
41-64-20b	LS RANCHES, INC.	L. CLARKSON	1947	5680	179	8	0-179	23-179	23R	1947	45R	31R	--	1947	--	U(D)	--	--
41-64-25a	LS RANCHES, INC.	BOLEY, HENRY, WEECH	1968	5535	275	12 8	0-49 0-274	-- --	10R	1968	70R	--	3.5	1968	--	U(D)	69	--
41-64-25ac	WINECUP HOT SPR.	--	--	--	--	--	--	--	FLOWING	9/88	>1000 GPM	--	--	--	--	PASTURE	61	--
41-64-25bb	LS RANCHES, INC.	BOLEY, HENRY, WEECH	1968	5555	90	8	+1-90	--	3R FLOWING	1968 4/18/81	35R	25R	1.4	1968	S,E	D	50	--
41-64-25bc	SIERRA-PACIFIC	WOODWARD-CLYDE	1981	5555	--	2	--	--	DRY	9/23/83	--	--	--	--	--	T	--	WOODWARD-CLYDE PIEZOMETER A-1
41-64-25ca	LS RANCHES, INC.	L. CLARKSON	1947	5555	59	8	0-59	15-59	10R	10/47	100R	--	--	1947	--	U(D)	152	--
41-64-25ca1	SIERRA-PACIFIC	WOODWARD-CLYDE	1981	5545	--	2	--	--	DRY	9/23/83	--	--	--	--	--	T	--	WOODWARD-CLYDE PIEZOMETER A-2
41-64-25cac1	LS RANCHES, INC.	L. CLARKSON	1947	5550	187	8	0-187	140-185	--	--	10E	--	--	4/18/81	S,E	S	--	--
41-64-25cac2	LS RANCHES, INC.	J.V. MUTH	1974	5550	192	8 8	+1.5-192 --	125-145 170-190	0 3.22	4/17/81 9/19/88	50R 12R	-- --	0.28 0.2	1974 1974	--	U(DS)	--	--
41-64-25db1	LS RANCHES, INC.	L. CLARKSON	1947	5560	68	8	0-68	30-68	30R	1947	40R	--	--	1947	--	U(D)	--	--
41-64-25db2	LS RANCHES, INC.	M.H. MUTH	1964	5565	70	8	0-63	30-60	33R 40.10 34.95	1964 4/18/81 9/19/88	50R	49R	--	1964	--	U(D)	--	--
41-64-26cd	SPRING 1 MI W WINECUP		--	--	--	--	--	--	FLOWING	9/88	400 GPM	--	--	--	--	S, PASTURE	9	--
41-64-27bb	LS RANCHES, INC.	--	--	5602	90	6	--	--	9.64 11.60	4/18/81 10/1/88	--	--	--	--	S,E	S	--	--
41-64-28bbb	LS RANCHES, INC.	L. CLARKSON	1947	5644	203	12	0-201	8-201	8R 8.16 3.05 1.88 2.84 4.57 3.48 4.75 5.25 5.52	11/47 11/21/81 4/22/85 3/1/86 6/18/86 10/1/86 2/11/87 9/22/87 12/8/87 10/1/88	45R 800R 180M	-- -- 25.6M	-- -- 10.8	1947 -- 11/21/81	T,G -- --	U(IRRIG) -- --	-- -- 50	-- -- --

SPRING/WELL NUMBER	ORIGINAL PERMITTED WELL OWNER	DRILLER	YEAR COMPLETED	ELEVATION (ft. MSL) 1/	DEPTH OF WELL (ft.)	CASING DATA: DIAMETER (inches)	CASING DATA: DEPTH INTERVAL (feet)	CASING DATA: SLOTTED INTERVAL (feet)	STATIC WATER LEVEL: DEPTH (ft.) 2/	STATIC WATER LEVEL: DATE	PUMPING DATA: RATE (gpm) 3/	PUMPING DATA: LEVEL (ft.) 4/	PUMPING DATA: SPECIFIC CAPACITY (gpm/ft)	PUMPING DATA: DATE	METHOD OF LIFT & POWER 5/	USE OF WATER 6/	WATER TEMPERATURE (F)	REMARKS
41-64-34da	LS RANCHES, INC.	W.H. MUTH AND RANCH IRRIGATION AND SUPPLY	1965	5602	201	16 10	0-101 96-201	63-101 100-200	13R 13.74 7.25	1963 4/17/81 9/20/88	200R 400R 150R	85R -- --	2.8 5.61 --	1965 -- 1/25/80	T	U(IRRIG)	49	--
41-64-35bc	LS RANCHES, INC.	W.H. MUTH	1965	5595	190	16	0-190	6-187	9R 7.30 8.43	1965 4/17/81 11/20/81	500R 510M	175R 121.7M	3.0 4.5	1965 11/20/81	T	U(IRRIG)	--	--
41-65-2bd	UNNAMED SPRING	--	--	5400	--	--	--	--	--	--	0.1 GPM	--	--	--	--	S	26	--
41-65-10ac	LS RANCHES, INC.	--	--	--	--	6	--	--	7.32	9/21/88	--	--	--	--	--	S	--	--
41-65-10ac1	SIERRA-PACIFIC	WOODWARD-CLYDE	1981	5420	--	2	--	--	7.95	9/23/83	--	--	--	--	--	T	--	WOODWARD-CLYDE PIEZOMETER D-2
41-65-10ac2	SIERRA-PACIFIC	WOODWARD-CLYDE	1981	5420	--	2	--	--	7.66	9/23/83	--	--	--	--	--	T	--	WOODWARD-CLYDE PIEZOMETER D-3
41-65-10ac2	SIERRA-PACIFIC	WOODWARD-CLYDE	1981	5420	--	2	--	--	8.17	9/23/83	--	--	--	--	--	T	--	WOODWARD-CLYDE PIEZOMETER D-4
41-65-10ac2	SIERRA-PACIFIC	WOODWARD-CLYDE	1981	5420	--	2	--	--	8.23	9/23/83	--	--	--	--	--	T	--	WOODWARD-CLYDE PIEZOMETER D-5
41-65-10db1	SIERRA-PACIFIC	WOODWARD-CLYDE	1981	5420	--	2	--	--	7.60	9/23/83	--	--	--	--	--	T	--	WOODWARD-CLYDE PIEZOMETER D-9
41-65-10db2	SIERRA-PACIFIC	WOODWARD-CLYDE	1981	5420	--	2	--	--	7.02	9/23/83	--	--	--	--	--	T	--	WOODWARD-CLYDE PIEZOMETER D-6
41-65-10db2	SIERRA-PACIFIC	WOODWARD-CLYDE	1981	5420	--	2	--	--	7.38	9/23/83	--	--	--	--	--	T	--	WOODWARD-CLYDE PIEZOMETER D-7
41-65-10db2	SIERRA-PACIFIC	WOODWARD-CLYDE	1981	5420	--	2	--	--	7.41	9/23/83	--	--	--	--	--	T	--	WOODWARD-CLYDE PIEZOMETER D-8
41-65-11bd1	SIERRA-PACIFIC	WOODWARD-CLYDE	1981	5412	--	2	--	--	8.28	9/23/83	--	--	--	--	--	T	--	WOODWARD-CLYDE PIEZOMETER C-7
41-65-11bd1	SIERRA-PACIFIC	WOODWARD-CLYDE	1981	5412	--	2	--	--	8.67	9/23/83	--	--	--	--	--	T	--	WOODWARD-CLYDE PIEZOMETER C-8

SPRING/WELL NUMBER	ORIGINAL PERMITTED WELL OWNER	DRILLER	YEAR COM-PLETED	ELEVATION (ft. MSL) 1/	DEPTH OF WELL (ft.)	CASING DATA			STATIC WATER LEVEL		PUMPING DATA				METHOD OF LIFT & POWER 5/	USE OF WATER 6/	WATER TEM-PERATURE (F)	REMARKS
						DIAMETER (inches)	DEPTH INTERVAL (feet)	SLOTTED INTERVAL (feet)	DEPTH (ft.) 2/	DATE	RATE (gpm) 3/	LEVEL (ft.) 4/	SPECIFIC CAPACITY (gpm/ft)	DATE				
41-65-11cb1	SIERRA-PACIFIC	WOODWARD-CLYDE	1981	5420	--	2	--	--	7.42	9/23/83	--	--	--	--	--	I	--	WOODWARD-CLYDE PIEZOMETER C-1
41-65-11cb1	SIERRA-PACIFIC	WOODWARD-CLYDE	1981	5420	--	2	--	--	7.58	9/23/83	--	--	--	--	--	I	--	WOODWARD-CLYDE PIEZOMETER C-2
41-65-11cb1	SIERRA-PACIFIC	WOODWARD-CLYDE	1981	5420	--	2	--	--	7.54	9/23/83	--	--	--	--	--	I	--	WOODWARD-CLYDE PIEZOMETER C-3
41-65-11cb2	SIERRA-PACIFIC	WOODWARD-CLYDE	1981	5415	--	2	--	--	9.02	9/23/83	--	--	--	--	--	I	--	WOODWARD-CLYDE PIEZOMETER C-9
41-65-11cb3	SIERRA-PACIFIC	WOODWARD-CLYDE	1981	5415	--	2	--	--	8.62	9/23/83	--	--	--	--	--	I	--	WOODWARD-CLYDE PIEZOMETER C-5
41-65-11cb3	SIERRA-PACIFIC	WOODWARD-CLYDE	1981	5415	--	2	--	--	8.83	9/23/83	--	--	--	--	--	I	--	WOODWARD-CLYDE PIEZOMETER C-6
41-65-21bb	SIERRA PACIFIC RESOURCES	R.D. REYNOLOS DRILLING	1988	5490	390	2	0-95	75-85	20.8	8/1/88	--	--	--	--	--	--	--	WOODWARD-CLYDE MONITORING WELL MW-4
41-65-30bb1	SIERRA-PACIFIC	WOODWARD-CLYDE	1981	5560	--	2	--	--	12.27	9/23/83	--	--	--	--	--	I	--	WOODWARD-CLYDE PIEZOMETER B-1
41-65-30bb1	SIERRA-PACIFIC	WOODWARD-CLYDE	1981	5560	--	2	--	--	13.67	9/23/83	--	--	--	--	--	I	--	WOODWARD-CLYDE PIEZOMETER B-2
41-65-30bb2	SIERRA-PACIFIC	WOODWARD-CLYDE	1981	5560	--	2	--	--	10.77	9/23/83	--	--	--	--	--	I	--	WOODWARD-CLYDE PIEZOMETER B-3
41-65-35ad	LS RANCHES, INC.	W.H. MUTH	1965	5512	600	12 8	0-365 355-600	50-365 355-600	58R 48.10 49.06 46.68 46.58 46.69 46.71 46.88 46.82 46.88 47.60	1964 4/18/81 11/17/81 6/7/85 3/7/86 10/8/86 2/11/87 10/6/87 12/8/87 2/25/88 10/6/88	50R 1345M	60R --	-- --	1964 11/19/81	T	U(IRRIG)	72	--

SPRING/WELL NUMBER	ORIGINAL PERMITTED WELL OWNER	DRILLER	YEAR COM-PLETED	ELEVATION (ft. MSL) 1/	DEPTH OF WELL (ft.)	CASING DATA			STATIC WATER LEVEL		PUMPING DATA				METHOD OF LIFT & POWER 5/	USE OF WATER 6/	WATER TEM-PERATURE (F)	REMARKS
						DIAMETER (inches)	DEPTH INTERVAL (feet)	SLOTTED INTERVAL (feet)	DEPTH (ft.) 2/	DATE	RATE (gpm) 3/	LEVEL (ft.) 4/	SPECIFIC CAPACITY (gpm/ft)	DATE				
41-65-35ad	SIERRA PACIFIC RESOURCES	R.D. REYNOLDS DRILLING	1989	5515	650	2	0-250	230-250	49.86	2/16/89	--	--	--	--	--	--	--	WOODWARD-CLYDE MONITORING WELL MW-17
41-65-35bd	LS RANCHES, INC.	W.H. MUTH	1964	5496	353	16	0-353	33-350	32R	1964	650R	200R	3.9	1964	T	U(IRRIG)	59	--
									32.01	4/18/81	533M	116.2M	6.3	11/17/81				
									31.80	11/17/81	699M	158.4M	5.6	11/20/81				
									33.16	11/20/81								
									29.81	6/7/85								
									29.66	3.7.86								
									29.92	10/8/86								
									29.97	2/11/87								
									30.08	6/18/87								
									30.21	10/6/87								
									30.14	12/8/87								
									30.21	2/25/88								
									31.40	10/6/88								
41-66-1cb	WINECUP RANCH	BOLEY, HENRY, WEECH	1970	6825	310	6	0-309	230-300	245	1/70	10R	--	--	1/70	B	S	COLD	WELL BAILED 10 GPM FOR 2.5HRS, DRAWDOWN = 40 FT
41-66-3	LS RANCHES, INC.	W.H. MUTH	1965	6170	587	--	--	--	135R	1965	0.25R	--	--	1965	--	U(S)	--	WELL DID NOT PRODUCE SUFFICIENT WATER, PLUGGED & ABANDONED
41-66-11bb	WINECUP RANCH	ALBERT YOUNG	1955	6890	155	6	0-47	137-147	110R	3/55	5R	--	--	3/55	B	S	COLD	WELL YIELDED 5GPM, NO DRAWDOWN DATA RECORDED
									100.57	6/20/67								
									99.75	6/18/87								
									99.70	10/14/87								
									99.56	12/8/87								
41-66-21ca	SIERRA PACIFIC RESOURCES	R.D. REYNOLDS DRILLING	1988	5784	160	--	--	--	--	--	--	--	--	--	--	--	--	WOODWARD-CLYDE MONITORING WELL MW-7, PLUGGED & ABANDONED
41-66-23cb	WINECUP RANCH	ALBERT YOUNG	1955	5905	192	6	0-151	NONE	32	2/55	5R	--	--	2/55	--	S	WARM	WELL YIELDED 5GPM, NO DRAWDOWN DATA RECORDED
									23.23	6/20/67								
									27.28	6/18/87								
									27.20	10/14/87								
									27.14	12/8/87								
41-66-24cb	--	--	--	--	--	6	--	--	--	--	--	--	--	--	--	S(U)	--	LOWER NINEMILE MTN. WELL
41-66-31cc1	SIERRA PACIFIC RESOURCES	R.D. REYNOLDS DRILLING	1988	5594	601	2	0-301	280-300	124.90	10/11/88	--	--	--	--	--	--	--	WOODWARD-CLYDE MONITORING WELL MW-12

SPRING/WELL NUMBER	ORIGINAL PERMITTED WELL OWNER	DRILLER	YEAR COMPLETED	ELEVATION (ft. MSL) 1/	DEPTH OF WELL (ft.)	CASING DATA			STATIC WATER LEVEL		PUMPING DATA				METHOD OF LIFT & POWER 5/	USE OF WATER 6/	WATER TEMPERATURE (F)	REMARKS
						DIAMETER (inches)	DEPTH INTERVAL (feet)	SLOTTED INTERVAL (feet)	DEPTH (ft.) 2/	DATE	RATE (gpm) 3/	LEVEL (ft.) 4/	SPECIFIC CAPACITY (gpm/ft)	DATE				
41-66-31cc2	SIERRA PACIFIC RESOURCES	R.D. REYNOLDS DRILLING	1988	5595	370	6	0-370	170-270 280-310 330-360	125.23	10/11/88	--	--	--	--	--	--	--	WOODWARD-CLYDE TEST WELL TW-12
41-66-33a	LS RANCHES, INC.	--	--	5653	380	6	0-380	--	124.96 124.91 125.50 127.10	6/18/87 10/6/87 2/25/88 10/6/88	--	--	--	--	C,W	S	--	--
41-67-6cd	--	--	--	--	--	--	--	--	--	--	--	--	--	--	--	--	--	--
41-67-22bc	LS RANCHES, INC.	HARRY BOLTON	1965	5516	495	6	0-496	385-494	364.48	12/10/88	--	--	--	--	C,D	S	71	--
41-69-7dd	LS RANCHES, INC.	BOLEY, HENRY, WEECH	1956	4965	54	6	0-54	33-45	30R 9.46	9/56 4/6/81	--	--	--	--	S,E	S	--	--
41-69-9	GAMBLE RANCHES	BOLEY, HENRY, WEECH	1956	5250	197	14	0-197	60-194	38R	9/56	--	--	--	--	--	IRRIG	--	NO WELL TEST PERFORMED
41-69-14ca	LS RANCHES, INC.	BOLEY, HENRY, WEECH	1971	5380	420	6	0-420	365-420	365R	1971	10R	--	0.6	1971	--	U(S)	--	--
41-69-21ccc	LS RANCHES, INC.	BOLEY, HENRY, WEECH	1956	4945	116	6	0-116	90-105	2R	9/56	--	--	--	--	--	U(S)	--	--
41-69-29dbc	LS RANCHES, INC.	ARNOLD ELSING	1980	4915	216	16	0-216	20-216	14R 9.00	6/80 11/13/81	950M	15.8M	140.1	11/13/81	T,D	IRRIG	58	--
41-69-36ab	LS RANCHES, INC.	HARRY BOLTON	1964	5059	401	6	0-401	--	310R	1964	10R	--	--	1964	--	S	--	--
41-70-30ad	LS RANCHES, INC.	R.D. REYNOLDS DRILLING	1983	5020	494	6	0-494	454-494	326R	10/6/83	20+R	--	--	10/83	A	S	60	WELL AIR PUMPED AT 20+GPM FOR 4HRS, 70FT DRAWDOWN OBSERVED.
42-64-27dd	LS RANCHES, INC.	W.H. MUTH	1965	6418	590	6	0-568	530-565	540R	1965	6R	545R	1.2	1965	C	S	--	--
42-65-6ca	BLACK ROCK SPRINGS	--	--	6840	--	--	--	--	FLOWING	9/88	5.5 GPM	--	--	--	--	S	12	--
42-65-10bd	LANDS OF SIERRA	R.D. REYNOLDS DRILLING	1982	5830	374	6	0-374	354-374	327R	7/82	10+R	--	--	7/82	A	S	COLD	WELL WAS AIR PUMPED AT 10+GM FOR 2HRS, 20FT DRAWDOWN OBSERVED
42-65-20da	LS RANCHES, INC.	HARRY BOLTON	1958	5742	450	6	0-397	310-395	310R 295.76	1958 6/19/67	--	--	--	--	C,W	S	--	--
42-65-32ba	LANDS OF SIERRA	R.D. REYNOLDS DRILLING	1982	5610	223	6	0-223	98-113 195-215	72R 132.05	7/24/82 9/21/88	10R	--	--	7/82	B	S	COLD	WELL BAILED 10GPM FOR 4HRS, 40FT DRAWDOWN OBSERVED.
42-65-32cc	UNNAMED SPRING	--	--	--	--	--	--	--	--	--	5.0 GPM	--	--	--	--	S	S	--

SPRING/WELL NUMBER	ORIGINAL PERMITTED WELL OWNER	DRILLER	YEAR COMPLETED	ELEVATION (ft. MSL) 1/	DEPTH OF WELL (ft.)	CASING DATA			STATIC WATER LEVEL		PUMPING DATA				METHOD OF LIFT & POWER 5/	USE OF WATER 6/	WATER TEMPERATURE (F)	REMARKS
						DIAMETER (inches)	DEPTH INTERVAL (feet)	SLOTTED INTERVAL (feet)	DEPTH (ft.) 2/	DATE	RATE (gpm) 3/	LEVEL (ft.) 4/	SPECIFIC CAPACITY (gpm/ft)	DATE				
42-65-35db1	SIERRA PACIFIC RESOURCES	R.D. REYNOLDS DRILLING	1988	5386	330	6	0-315	60-100 140-150 160-170 190-260 285-295	3.00	10/6/88	--	--	--	--	--	--	--	WOODWARD-CLYDE TEST WELL TW-1
42-65-35db2	SIERRA PACIFIC RESOURCES	R.D. REYNOLDS DRILLING	1988	5385	540	2	0-200	180-200	1.20	10/6/88	--	--	--	--	--	--	--	WOODWARD-CLYDE MONITORING WELL MW-1
42-66-8ad1	SIERRA-PACIFIC	WOODWARD-CLYDE	1981	5320	--	2	0-37	--	27.55 29.65	9/23/83 10/7/88	--	--	--	--	--	--	--	WOODWARD-CLYDE PIEZOMETER E-1
42-66-8ad2	SIERRA-PACIFIC	WOODWARD-CLYDE	1981	5320	--	2	--	--	--	--	--	--	--	--	--	--	--	WOODWARD-CLYDE PIEZOMETER E-2
42-66-8ad3	SIERRA-PACIFIC	WOODWARD-CLYDE	1981	5320	--	2	--	--	--	--	--	--	--	--	--	--	--	WOODWARD-CLYDE PIEZOMETER E-3
42-66-8ad4	SIERRA-PACIFIC	WOODWARD-CLYDE	1981	5320	--	2	--	--	--	--	--	--	--	--	--	--	--	WOODWARD-CLYDE PIEZOMETER E-4
42-66-9aa	WINECUP RANCH	HOOD & ROWDEN	1955	6420	255	6	0-255	225-255	205R	8/55	--	--	--	--	--	S	50	--
42-66-19db	SIERRA PACIFIC RESOURCES	R.D. REYNOLDS DRILLING	1988	5376	526	--	--	--	--	--	--	--	--	--	--	--	--	WOODWARD-CLYDE MONITORING WELL MW-6, PLUGGED & ABANDONED
42-66-35ad	--	--	--	--	--	6	--	--	--	--	--	--	--	--	--	--	--	--
42-66-27aa	LS RANCHES, INC.	--	--	--	340	6	0-340	--	--	--	--	--	--	--	C,W	S	--	HIDDEN WELL
42-67-25aa	LS RANCHES, INC.	J.B. REYNOLDS DRILLING	1957	6560	182	16	0-182	30-175	20R	1957	--	--	--	--	--	U(IRRIG)	--	--
42-68-2ab	BUREAU OF LAND MANAGEMENT	RALPH DENTON DRILLING	1967	6170	356	6	0-356	315-356	300R	7/67	15R	--	--	7/15	B	S	--	WELL BAILED 15GPM FOR 1HR, 20FT DRAWDOWN OBSERVED
42-68-5a	GAMBLE RANCHES	J.B. REYNOLDS DRILLING	1955	5910	233	6	0-233	204-230	187	11/55	--	--	--	--	--	S	--	--
42-68-29ba	LS RANCHES, INC.	J.B. REYNOLDS DRILLING	1955	5120	96	6	0-96	50-90	40R 42.39 38.20	11/7/55 6/21/67 4/18/81	--	--	--	--	C,W	U(D)	--	--
42-68-35ac	LS RANCHES, INC.	BOLEY, HENRY, WEECH	1957	5026	320	20	0-144	35-100	23R 20.89 23.55	4/57 4/16/81 11/15/81	700R 700E	-- --	-- --	11/15/81 --	I,E	IRRIG	55	--

SPRING/WELL NUMBER	ORIGINAL PERMITTED WELL OWNER	DRILLER	YEAR COM-PLETED	ELEVATION (ft. MSL) 1/	DEPTH OF WELL (ft.)	CASING DATA			STATIC WATER LEVEL		PUMPING DATA				METHOD OF LIFT & POWER 5/	USE OF WATER 6/	WATER TEM-PERATURE (F)	REMARKS
						DIAMETER (inches)	DEPTH INTERVAL (feet)	SLOTTED INTERVAL (feet)	DEPTH (ft.) 2/	DATE	RATE (gpm) 3/	LEVEL (ft.) 4/	SPECIFIC CAPACITY (gpm/ft)	DATE				
42-68-35ad	LS RANCHES, INC.	--	1968	5018	142	16	--	--	31R 20R	9/30/68 6/79	1000R	125R	10.6	9/30/68	T,E	IRRIG	--	--
42-69-8ac	CRITTENDEN SPRINGS	--	--	--	--	--	--	--	FLOWING	9/88	800 GPM	--	--	--	--	D,S	16	--
43-63-4aa	AGEE, AGEE, BOIES	AVERY BLANCHARD	1949	5570	65	5	0-65	45-65	28R	9/49	--	--	--	--	--	D,S	--	--
43-63-14bd	EYER BOIES	J.B. REYNOLDS DRILLING	1961	5570	200	16	0-200	7-195	7R	6/61	250R	--	--	6/61	B	IRRIG	--	WELL TESTED AT 250GPM FOR 8HRS, 123 FT OF DRAWDOWN
43-63-23ab	EYER BOIES	J.B. REYNOLDS DRILLING	1961	5640	52	16	0-52	12-51	12R	6/61	400R	--	--	6/61	--	IRRIG	COLD	WELL PUMPED 400GPM FOR 8HRS, 28 FT OF DRAWDOWN OBSERVED
43-63-27bb	BUREAU OF LAND MANAGEMENT	R.D. REYNOLDS DRILLING	1954	5775	154	6	0-154	70-152	84R	11/54	--	--	--	--	--	S	--	--
43-63-29db	BUREAU OF LAND MANAGEMENT	R.D. REYNOLDS DRILLING	1982	5905	188	6	0-188	168-188	120R	4/82	10+R	--	--	4/82	B	S	COLD	WELL BAILED 10+GPM FOR 3HRS, 10 FT OF DRAWDOWN OBSERVED.
43-65-3ca	UNNAMED SPRING	--	--	6800	--	--	--	--	--	--	16 GPM	--	--	--	--	U	12	--
43-65-8cc	UNNAMED SPRING	--	--	7800	--	--	--	--	--	--	0.5 GPM	--	--	--	--	U	13	--
43-65-10aa	UNNAMED SPRING	--	--	6820	--	--	--	--	--	--	SEEP	--	--	--	--	U	--	--
43-65-15ba	UNNAMED SPRING	--	--	6600	--	--	--	--	--	--	18.0 GPM	--	--	--	--	U	17	--
43-65-27cb	UNNAMED SPRING	--	--	6340	--	--	--	--	--	--	2240 GPM	--	--	--	--	U	10	FLOW VOLUME REPORTED BY B.L.M.
43-65-27da	UNNAMED SPRING	--	--	--	--	--	--	--	--	--	2240 GPM	--	--	--	--	U	--	FLOW VOLUME REPORTED BY B.L.M.
43-65-28aa	--	--	--	7000	--	--	--	--	--	--	1.0 GPM	--	--	--	--	U	16	--
43-65-32cc	CCC SPRING	--	--	7200	--	--	--	--	--	--	5.0 GPM	--	--	--	--	S	12	--
43-65-33ca	--	--	--	6500	--	--	--	--	--	--	225 GPM	--	--	--	--	S	16	FLOW VOLUME REPORTED BY B.L.M.
43-66-6bd	--	--	--	6020	--	--	--	--	--	--	0.2 GPM	--	--	--	--	U	10	--
43-66-13ac	CHICKEN SPRING	--	--	5440	--	--	--	--	FLOWING	9/88	2.0 GPM	--	--	--	--	S	23	--
43-66-18dd	WINECUP RANCH	HARRY BOLTON	1958	5905	425	6	0-412	240-409	212R	8/58	--	--	--	--	--	S	--	--

SPRING/WELL NUMBER	ORIGINAL PERMITTED WELL OWNER	DRILLER	YEAR COMPLETED	ELEVATION (ft. MSL) 1/	DEPTH OF WELL (ft.)	CASING DATA			STATIC WATER LEVEL		PUMPING DATA				METHOD OF LIFT & POWER 5/	USE OF WATER 6/	WATER TEMPERATURE (F)	REMARKS
						DIAMETER (inches)	DEPTH INTERVAL (feet)	SLOTTED INTERVAL (feet)	DEPTH (ft.) 2/	DATE	RATE (gpm) 3/	LEVEL (ft.) 4/	SPECIFIC CAPACITY (gpm/ft)	DATE				
43-66-25d	ECCLES RANCH	--	--	--	28	60	--	--	10.29	7/20/50	--	--	--	--	--	D	--	--
									12.73	6/67								
									15.21	2/28/68								
									8.36	4/29/69								
									11.81	3/27/70								
									10.50	4/1/71								
									11.63	4/3/72								
									10.40	4/4/73								
									9.52	3/13/74								
									11.95	3/13/75								
									10.72	3/18/76								
									13.00	3/10/77								
									13.54	4/18/79								
									9.11	4/17/79								
									11.36	3/20/80								
									13.02	3/19/81								
									11.24	3/30/82								
									8.58	4/12/83								
									7.07	4/25/85								
									8.28	4/22/86								
									10.05	6/19/86								
									12.31	2/11/87								
									15.20	10/88								
43-66-28ad	LS RANCHES, INC.	HARRY BOLTON	1958	5479	450	--	--	--	--	--	--	--	--	--	--	--	--	DRY HOLE
43-66-35-1	WESTPAC UTILITIES	HUMBOLDT DRILLING	1988	5350	355	16	0-355	115-140 160-335	9R	1/88	450R	--	--	1/88	--	IRRIG	--	--
43-66-35bd	LS RANCHES, INC.	--	--	5260	120	6	--	--	--	--	10E	--	--	4/18/81	C,D	S	52	--
43-67-4ab	GAMBLE RANCHES	J.B. REYNOLDS DRILLING	1956	5840	264	6	198-264	190-260	190R	10/85	--	--	--	--	--	S	--	--
43-67-16dd	GAMBLE RANCHES	J.B. REYNOLDS DRILLING	1956	5760	220	6	0-220	170-216	152R	10/55	--	--	--	--	--	S	COLD	--
43-67-18bc	MUD SPRING	--	--	5320	--	--	--	--	--	--	0.1 GPM	--	--	--	--	S	21	--
43-67-31bd1	SIERRA-PACIFIC	WOODWARD-CLYDE	1981	5230	--	2	--	--	12.39	9/23/83	--	--	--	--	--	T	--	WOODWARD-CLYDE PIEZOMETER F-5
43-67-31bd1	SIERRA-PACIFIC	WOODWARD-CLYDE	1981	5230	--	2	--	--	12.98	9/23/83	--	--	--	--	--	T	--	WOODWARD-CLYDE PIEZOMETER F-6
43-67-31bd2	SIERRA-PACIFIC	WOODWARD-CLYDE	1981	5240	--	2	--	--	14.36	9/23/83	--	--	--	--	--	T	--	WOODWARD-CLYDE PIEZOMETER F-1

SPRING/WELL NUMBER	ORIGINAL PERMITTED WELL OWNER	DRILLER	YEAR COMPLETED	ELEVATION (ft. MSL) 1/	DEPTH OF WELL (ft.)	CASING DATA			STATIC WATER LEVEL		PUMPING DATA				METHOD OF LIFT & POWER 5/	USE OF WATER 6/	WATER TEMPERATURE (F)	REMARKS
						DIAMETER (inches)	DEPTH INTERVAL (feet)	SLOTTED INTERVAL (feet)	DEPTH (ft.) 2/	DATE	RATE (gpm) 3/	LEVEL (ft.) 4/	SPECIFIC CAPACITY (gpm/ft)	DATE				
43-67-31bd2	SIERRA-PACIFIC	WOODWARD-CLYDE	1981	5240	--	2	--	--	14.68	9/23/83	--	--	--	--	--	T	--	WOODWARD-CLYDE PIEZOMETER F-2
43-67-31db1	SIERRA-PACIFIC	WOODWARD-CLYDE	1981	5240	--	2	--	--	18.12	9/23/83	--	--	--	--	--	T	--	WOODWARD-CLYDE PIEZOMETER F-3
43-67-31db1	SIERRA-PACIFIC	WOODWARD-CLYDE	1981	5240	--	2	--	--	20.99	9/23/83	--	--	--	--	--	T	--	WOODWARD-CLYDE PIEZOMETER F-4
43-67-32bc	WINECUP RANCH	BOLEY, HENRY, WEECH	1970	5450	100	6	0-100	20-53 71-90	20	2/70	40R	--	--	4/70	8	S	COLD	WELL BAILED 40GPM FOR 1HR, NO DRAWDOWN OBSERVED
43-68-10bb	COLD SPRING	--	--	6840	--	--	--	--	--	--	3.0 GPM	--	--	--	--	S	8	--
43-68-10cd	INDIAN SPRING	--	--	6720	--	--	--	--	FLOWING	9/88	2.6 GPM	--	--	--	--	S	--	--
43-68-11ac	UTAH INTRNTNL	PAUL WILLIAMS & SONS	1980	--	955	6	--	--	--	--	--	--	--	--	--	T	--	TEST HOLE, NO WATER ENCOUNTERED DURING DRILLING.
43-68-12da	UTAH INTRNTNL	PAUL WILLIAMS & SONS	1980	--	880	8	--	--	500R	12/80	30-40R	--	--	12/80	A	T	COOL	TEST HOLE, NO CASING INSATLLED.
43-68-17aa	MESQUITE LAND CO.	BOLEY, HENRY, WEECH	1970	5020	170	--	--	--	--	--	--	--	--	--	--	--	--	DRY HOLE
43-68-20ad	MESQUITE LAND CO.	ALBERT SMITH	1972	6690	159	2	0-156	114-156	--	--	--	--	--	--	--	S	50	HORIZONTAL WELL
43-68-20ad	EIGHTEENMILE SPRNG	--	--	5500	--	--	--	--	FLOWING	9/88	0.4 GPM	--	--	--	--	S	20	--
43-68-26ac	LS RANCHES, INC.	R.D. REYNOLDS DRILLING	1983	6560	320	6	0-320	158-215 235-264 270-287	85R	7/83	10R	--	--	7/83	A	S	COLD	WELL AIR PUMPED 10GPM FOR 4HRS, 235FT DRAWDOWN OBSERVED
43-69-12ac	UNNAMED SPRING	--	--	6400	--	--	--	--	--	--	0.2 GPM	--	--	--	--	S	22	--
43-69-14ba	UNNAMED SPRING	--	--	6100	--	--	--	--	--	--	SEEP	--	--	--	--	U	--	--
43-69-24db	UNNAMED SPRING	--	--	6200	--	--	--	--	--	--	5.0 GPM	--	--	--	--	U	9	--
44-69-21bb	UNNAMED SPRING	--	--	--	--	--	--	--	--	--	0.1 GPM	--	--	--	--	U	11	--
44-69-25bb	UNNAMED SPRING	--	--	6800	--	--	--	--	--	--	5.0 GPM	--	--	--	--	S	17	--
44-69-25cc	BULL SPRING	--	--	6700	--	--	--	--	--	--	2.0 GPM	--	--	--	--	S	14	--
44-69-27ac	UNNAMED SPRING	--	--	6600	--	--	--	--	--	--	0.1 GPM	--	--	--	--	--	26	--
44-69-27cc	UNNAMED SPRING	--	--	6300	--	--	--	--	--	--	2.0 GPM	--	--	--	--	U	14	--

SPRING/WELL NUMBER	ORIGINAL PERMITTED WELL OWNER	DRILLER	YEAR COM-PLETED	ELEVATION (ft. MSL) 1/	DEPTH OF WELL (ft.)	CASING DATA			STATIC WATER LEVEL		PUMPING DATA				METHOD OF LIFT & POWER 5/	USE OF WATER 6/	WATER TEM-PERATURE (F)	REMARKS
						DIAMETER (inches)	DEPTH INTERVAL (feet)	SLOTTED INTERVAL (feet)	DEPTH (ft.) 2/	DATE	RATE (gpm) 3/	LEVEL (ft.) 4/	SPECIFIC CAPACITY (gpm/ft)	DATE				
44-69-28db	UNNAMED SPRING	--	--	6300	--	--	--	--	--	--	1.0 GPM	--	--	--	--	--	18	--
44-69-30ad	EMIGRANT SPRING	--	--	--	--	--	--	--	FLOWING	9/88	200 GPM	--	--	--	--	S	15	--
44-69-33bd	UNNAMED SPRING	--	--	6900	--	--	--	--	--	--	0.1 GPM	--	--	--	--	S	14	--
44-69-34bd	UNNAMED SPRING	--	--	--	--	--	--	--	--	--	0.3 GPM	--	--	--	--	S	--	--
44-69-35db	LITTLE ROCK SPRING	--	--	6400	--	--	--	--	--	--	3.0 GPM	--	--	--	--	S	17	--
44-69-36da	UNNAMED SPRING	--	--	6600	--	--	--	--	--	--	SEEP	--	--	--	--	--	22	--

1/ ELEVATION ESTIMATED FROM U. S. GEOLOGICAL SURVEY TOPOGRAPHIC MAPS OR DETERMINED BY ELEVATION SURVEY PERFORMED IN 1988.

2/ WATER LEVEL REPORTED (R) BY OWNER, DRILLER, OR NEVADA COOPERATIVE EXTENSION SERVICE. NO LETTER FOLLOWING WATER LEVEL INDICATES IT WAS MEASURED BY U. S. GEOLOGICAL SURVEY, WILLIAM F. GUYTON & ASSOCIATES, OR WOODWARD-CLYDE ON THE DATE PROVIDED.

3/ IDENTIFYING LETTERS: E = ESTIMATED BY OWNER OR ESTIMATED BY WILLIAM F GUYTON & ASSOCIATES IN APRIL OR NOVEMBER 1981.
M = MEASURED BY WILLIAM F. GUYTON & ASSOCIATES ON DATE PROVIDED.
R = REPORTED BY OWNER, DRILLER, PUMP CREW, OR NEVADA COOPERATIVE EXTENSION SERVICE.

4/ IDENTIFYING LETTERS: M = MEASURED BY WILLIAM F. GUYTON & ASSOCIATES ON DATE PROVIDED.
R = REPORTED BY OWNER, DRILLER, PUMP CREW, OR NEVADA COOPERATIVE EXTENSION SERVICE.

5/ IDENTIFYING LETTERS
C = CYLINDER PUMP
S = SUBMERSIBLE PUMP
T = TURBINE PUMP
B = BAILER
D = DIESEL
E = ELECTRIC
G = GASOLINE
W = WINDMILL
A = AIR PUMP

6/ IDENTIFYING LETTERS:
D = DOMESTIC
IND = INDUSTRIAL
IRRIG = IRRIGATION
T = TEST WELL
S = STOCK
U = UNUSED
U(IRR), U(D), ETC. = UNUSED OR ABANDONED WELL WITH FORMER USE INDICATED
MUNICIP = MUNICIPAL USAGE

APPENDIX J
CALCULATION OF GROUNDWATER FLOW VOLUME THROUGH SELECTED HYDROGEOLOGIC CROSS-SECTIONS AND ESTIMATES OF VOLUMETRIC GROUNDWATER RECHARGE RATES IN THE TOANO DRAW SUBBASIN USING RESULTS FROM TRITIUM ANALYSIS

APPENDIX J

1.0 CALCULATION OF GROUNDWATER FLOW THROUGH HYDROGEOLOGIC CROSS SECTIONS DEVELOPED FROM TDEM GEOPHYSICAL PROFILES

Estimates of the volume of groundwater flowing through hydrogeologic cross sections were calculated utilizing subsurface profiles developed from a TDEM survey performed in the project vicinity (Figures J-1 and J-2). Development of the geophysical profiles is discussed in Section 3.2.2; location of the profiles is depicted on Figure 3-2.

The volume of groundwater flowing through a cross section was calculated from the equation:

$$Q = kiA$$

where

Q = volume of water, cubic feet per day
k = hydraulic conductivity of aquifer materials, feet/day
i = hydraulic gradient, dimensionless
A = cross-sectional area of saturated aquifer lying between lines of equal hydraulic head, square feet

The mean hydraulic conductivity of aquifer materials was estimated from available aquifer test data for wells in the vicinity of each profile. The cross-sectional area of each profile was calculated from scale drawings. The hydraulic gradient was estimated from hydraulic head differences in wells oriented parallel to flow path lines oriented normal to the cross-sectional plane.

2.0 ESTIMATES OF VOLUMETRIC GROUNDWATER RECHARGE RATES IN THE TOANO DRAW SUBBASIN USING RESULTS FROM TRITIUM ANALYSES

Estimates of volumetric groundwater recharge rates were calculated using results from laboratory analysis for the presence of tritium in groundwater samples. Tritium is a radioactive isotope of hydrogen that has a half-life of 12.26 years. Tritium is present in atmospheric (meteoric) water and its presence in groundwater is a good indicator that some component of the groundwater is a result of recharge within the past few decades. Tritium was analyzed in water from eight wells in the Toano Draw Subbasin and was detected in four of the wells: TW-3, TW-15, Toano No. 1 (40-65-24bd), and Fivemile Draw (41-66-33a).

For estimating purposes, it was assumed that:

1. Groundwater recharge occurs on a large scale in areas underlying the Quaternary and Late Tertiary channelized alluvium the areal extent of which has been estimated to total approximately 12,200 acres based on geologic mapping (Figure 3-1).

2. The average vertical linear velocity of groundwater moving through the vadose zone is equal to the distance between the ground surface and the water table, divided by the maximum travel time indicated by the presence of tritium, 35 years. This is a conservative assumption in that groundwater containing tritium could be less than 35 years and thus actual recharge rates would be higher than the estimated rate. The average vertical linear velocity was estimated from the following wells which had detectable quantities of tritium.

WELL	TRITIUM CONCENTRATION tritium units, T(u)	DEPTH TO WATER (ft.)	VERTICAL LINEAR VELOCITY (ft./yr.)
TW-3	0.06 +- 0.09	192.5	5.5*
TW-15	0.15 +- 0.09	211.9	6.1
Toano #1	0.60 +- 0.09	98.0	2.8
Fivemile Draw	1.25 +- 0.09	127.1	3.6
AVERAGE VERTICAL LINEAR VELOCITY =			4.2 ft./yr.

Note: *value not used in calculating average vertical linear velocity because analytical error may indicate that tritium is not present.

3. The well locations at which tritium was detected are representative of recharge rates within the central portions of the Subbasin that are covered by Quaternary and Late Tertiary channelized alluvium.

4. The volumetric flow rate of water moving through the vadose zone is equal to the average vertical linear velocity multiplied by the effective porosity of the sediment that transmits moisture.

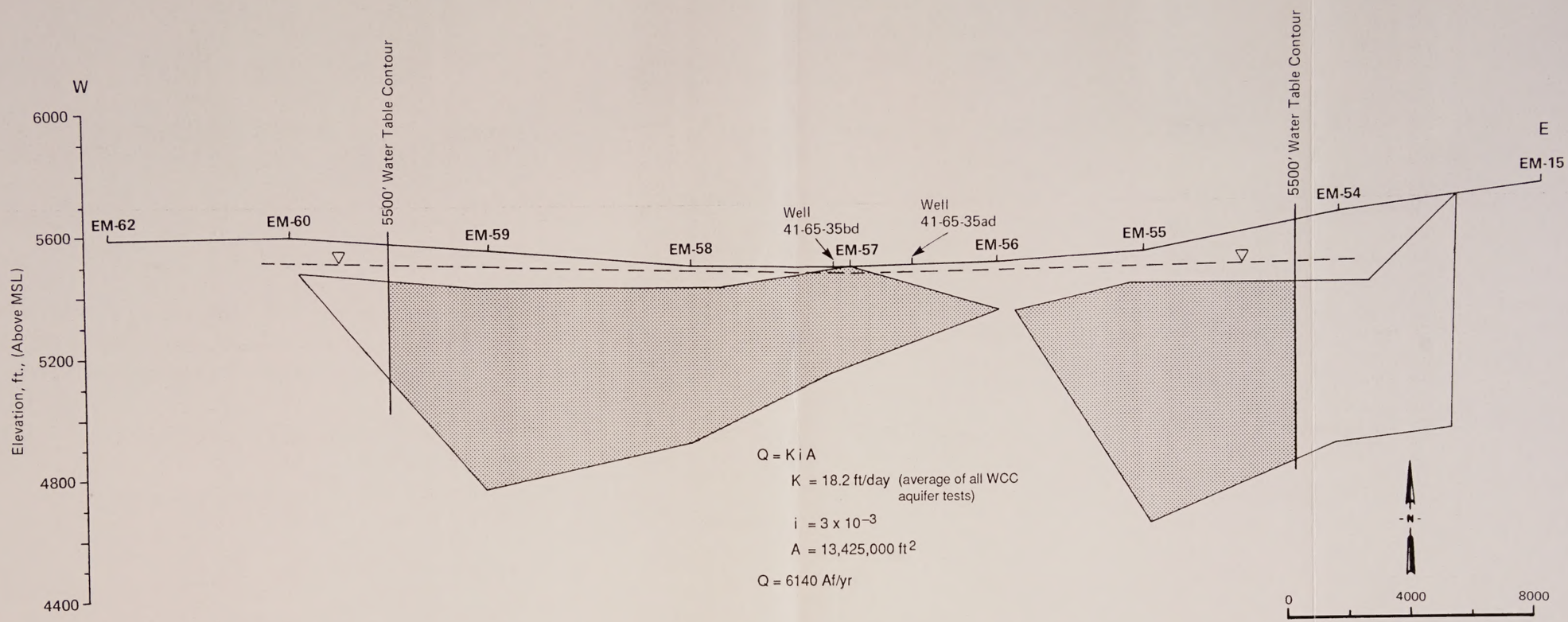
Groundwater recharge rates were estimated using the following relationship:

$$R = VoA$$

Where, R = volumetric recharge rate, acre-feet/year
V = average vertical linear velocity, feet/year
o = ratio of void space that transmits water to total void space of the vadose zone sediment, dimensionless
A = area of channelized unconsolidated alluvium, 12,200 acres

Volumetric recharge rates were estimated assuming the void space that transmits moisture is equal to 15, 20, and 25 percent of the vadose zone sediment. Thus, estimates of volumetric recharge rates in the Toano Draw subbasin for the stated saturated effective porosity are:

o = 15%, R = 7,690 acre-feet/year
o = 20%, R = 10,250 acre-feet/year
o = 25%, R = 12,810 acre-feet/year



LEGEND

Cross-sectional area of saturated aquifer material as interpreted from TDEM geophysical survey

Water table surface

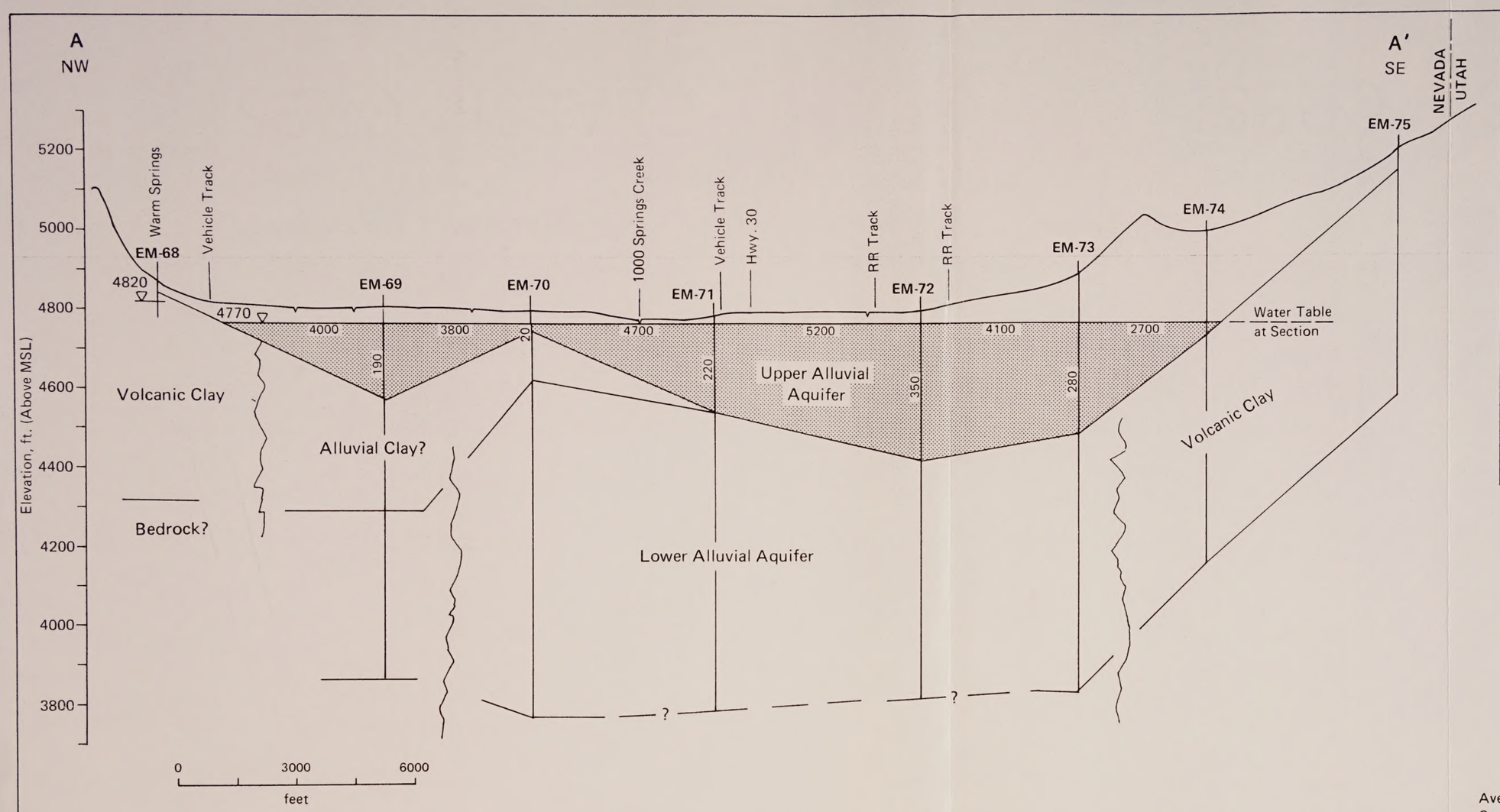
EM
|
TDEM station

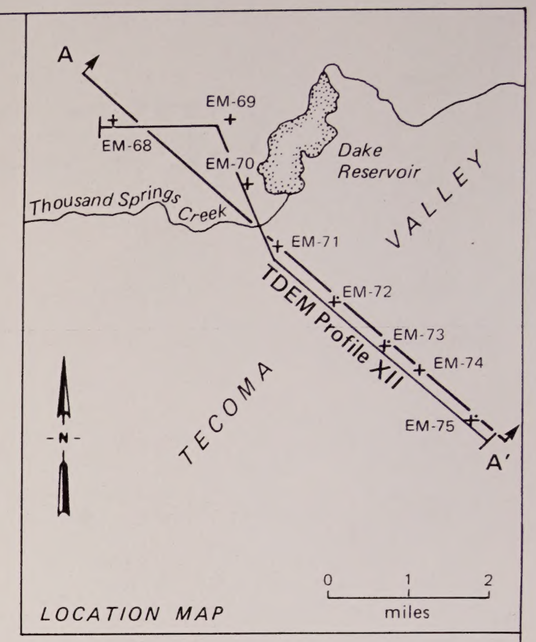
Average Hydraulic Conductivity of All Aquifer Tests Performed in Toano Draw Subbasin

WELL	K (ft/day)
41-65-35ad	22.7
41-65-35bd	4.6
TW-1	6.8
TW-3	4.1
TW-12	17.1
TW-14	15.8
TW-15	56.2

Average K = 18.2 ft/day

Project No. 90270B	Thousand Springs Power Plant	CALCULATION OF GROUNDWATER FLOW RATE THROUGH HYDROGEOLOGIC CROSS-SECTION (Developed from TDEM Geophysical Profile XII, Figure 3-2)	Figure J-1
Woodward-Clyde Consultants			





LEGEND

Cross-sectional area of saturated upper alluvial aquifer material as interpreted from TDEM geophysical survey (estimate is for flow through shaded area only; it does not account for flow through deeper aquifers)

Water table surface

EM — TDEM station

GROUNDWATER FLOW ESTIMATE

$Q = K\ i\ A$

$K = 270$ ft./day

$i = 0.003$

$A = 4{,}400{,}000\ ft^2$

$Q = 3{,}564{,}000\ ft^3/day$

$= 30{,}000$ AF/yr

Average Hydraulic Conductivity of Wells in Vicinity of Cross Section, Estimated From Specific Capacity Data; All Wells Are Less Than 180 Feet Deep

WELL	K (ft/day)
40-69-ba	790
40-69-22bc	98
40-69-14cb	58
40-69-cd	195 (avg. of high and low values)
40-69-15dd	101
40-69-16cc	457
40-69-23db	180
	Average = 270 ft./day

Project No. 90270B	Thousand Springs Power Plant	ESTIMATE OF GROUNDWATER FLOW EASTWARD THROUGH TECOMA VALLEY CROSS-SECTION (SHADED AREA ONLY)	Figure J-2
Woodward-Clyde Consultants			